

A
R E P L Y

TO THE

ANSWER of the Rev. Dr. MASKELYNE,

ASTRONOMER ROYAL, &c.

E R R A T A

- Page v. Preface, last line, *for nothing, read and nothing.*
 — 64 line 3. *for profels, read profels myself.*
 — 94 line 10. *for 24", read 0", 24.*
 — line 12. *for 1'.61" read 1", 61.*
 — line 13. *for 1'.37", read 1", 37.*
 — 109 line 5. *for it, read them.*
 — 127 line 1. *for formery, read formerly.*
 — 164 line 19. *for things, read thing.*

In the fhort Explanation by Count Bruhl.

- Page v. line 21. *for first, read last.*
 — 10. line 10. *for compliment, read complement.*
 — 14. line 17. *for himself he, read he himself.*

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533.e.25.
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A
R E P L Y

TO THE
ANSWER of the Rev. Dr. MASKELYNE,
ASTRONOMER ROYAL,
TO
A NARRATIVE OF FACTS,
RELATING TO SOME
TIME-KEEPERS,
CONSTRUCTED BY
Mr. THOMAS MUDGE,
FOR THE
DISCOVERY OF THE LONGITUDE AT SEA, &c.

By *THOMAS MUDGE*, Jun.
OF LINCOLN'S INN. *R*

TO WHICH IS ADDED,
A SHORT EXPLANATION
OF
THE MOST PROPER METHODS OF CALCULATING
A MEAN DAILY RATE,

With Remarks on some Passages in Dr. MASKELYNE's Answer.

BY HIS EXCELLENCY
The COUNT DE BRUHL.

L O N D O N:
PRINTED FOR THOMAS PAYNE, NEAR THE MEWS GATE.
MDCCXCII.

R. E. P. Y.

ANSWER of the Rev. Dr. MASKELLINE,

ASTRONOMER ROYAL,

A NARRATIVE of FACTS

RELATIVE TO SOME

TIME-KEEPERS

CONSTRUCTED BY

MR. THOMAS MUDGE.

FOR THE

DISCOVERY OF THE LONGITUDE AT SEA.

BY THOMAS MUDGE, JUNR.

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TO WHICH IS ADDED,

A SHORT EXPLANATION

OF THE MOST PROPER METHOD OF CORRECTING

A MEAN DAILY RATE.

WITH REMARKS ON THE USE OF THE BAROMETRIC THERMOMETER.

BY HIS EXCELLENCY

THE COUNT DE BRUNN.

LONDON.

PRINTED FOR THOMAS MUDGE, NEAR THE NEWS-GATE.

MDCCLXXXII.

TO
HIS EXCELLENCY

COUNT BRUHL,

PRIVY COUNSELLOR OF HIS MOST SERENE HIGHNESS
THE ELECTOR OF SAXONY,

HIS ENVOY EXTRAORDINARY AT THE COURT
OF GREAT BRITAIN,

AND KNIGHT OF THE POLISH ORDER OF THE
WHITE EAGLE, &c. &c. &c.

SIR,

THE book, which by your Excellency's permission I have the honor to dedicate to you, has two objects in view—to vindicate the reputation of my Father, and to justify his pretensions to a reward from the Public for the improvements which he has made in the construction of Time-keepers. To you, Sir, who have distinguished him by your regard, protection, and friendship, for more than thirty years; who during all that

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time

time have invigorated his labours, and promoted his progress, in this ingenious and useful branch of mechanism, by your encouragement and approbation, neither his fame nor his success can be matter of indifference. You have indeed proved, that you make them your concern by frequent testimonies of his merit and ingenuity, and by your solicitude to obtain for him a suitable reward for his discoveries. These circumstances lead me to hope, that a book written for the purposes which I have mentioned, will be favourably received by you. And I would gladly make use of this opportunity to declare how much both my Father and myself feel ourselves indebted to your Excellency. Your goodness to him, and your exertions to serve him, are alone sufficient grounds for our warmest gratitude. Your attention and kindness to me have greatly added to my obligations on his account. But I am unable

able to express fully my sense of these favours, and must content myself with saying, that the effect which they have produced on my mind is, that I esteem, honor, and revere you.

I have the honor to be,
With the greatest gratitude and respect,
Your Excellency's most obliged,
And most obedient humble servant,

THOMAS MUDGE.

able to express this in terms of value
favourable and disadvantageous with
regard to the effect which they have
directly on my mind in that I believe have
and these would be the same in all

cases of this kind
and I believe that the effect
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and that the effect would be the same

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THOMAS MUDGE

P R E F A C E.

SINCE the publication of my Narrative relative to the Time-keepers constructed by my Father, and the treatment they have met with from the Astronomer Royal, I have been informed, that, in the opinion of some very respectable characters, I have expressed myself with rather too much warmth in my animadversions on Dr. *Maskeelyne's* conduct. Having always anxiously wished to repress the growth of every angry and vindictive sentiment in my breast, I am very sorry to have been under the influence of circumstances, which have called forth from my pen, language that has been thought to militate against the principles of moderation. But though it may be still thought that I should have acquitted myself better, if I had been less strong in my reprehensions; yet, I trust, when the causes, that operated upon my mind are considered, men of liberality, and feeling, will be disposed to allow, that there is much to be urged in my behalf. To me, who have not been in the habit of addressing the Public, it was a very unpleasant thing to write at all; nothing but the

the strongest conviction, that my Father had been treated with great injustice, would have induced me to overcome that disinclination. But while I considered him in the light of a man, who, after having gone through a long life in the exercise of the greatest mechanical talents, and with an unspotted integrity,* qualities which had procured him the friendship of some of the most estimable part of mankind, had not only had the ingenious labours of near twenty years unjustly rejected by Dr. *Maskeelyne*, in his character of Astronomer Royal, as not deserving the public attention; but had also had his integrity impeached, by a charge of having endeavoured to assume to himself the merit that was due to another; could I, standing in the character of a son, be otherwise than greatly affected at such treatment: and is it matter of much wonder, that in relating such circumstances, as I thought tended to shew the improper, and uncandid, behaviour of Dr. *Maskeelyne*, I should

* The abilities and integrity of my Father were so well known to the King of Spain, who was the predecessor to the late King, that he had, from the death of Mr. Graham, until the King himself died, an unlimited commission from his Majesty to exercise his mechanical talents in the production of any thing that he thought would be deserving of his Majesty's attention.

occasionally have made use of terms, which discovered some degree of resentment; more especially, when it is remembered, that my Father had wholly outlived the power of fighting his own battle, and that one of the strongest proofs a grateful son could give of the obligations he owed to a venerable parent, was in shewing himself animated in the defence of his character, when he was no longer able to defend it himself.

Another complaint has been made against me, though I believe by Dr. Maskelyne only, which is, that I have been guilty of great presumption, in dedicating my Narrative to the Earl of Chatham without his Lordship's permission. As I have a most unfeigned respect for my Lord Chatham's character, and should be very much hurt, if I believed his Lordship thought me guilty of presumption or indecency in the liberty taken by me in addressing my pamphlet to him, I will assure both his Lordship, and the Public, that when I did it, I had not the most distant idea I was doing wrong. Had my book not been intentionally written for the purpose of calling in question the conduct of a public officer; but, on the contrary, had only contained, what I deemed useful information on any subject deserving of public attention; though I have not the honor of being myself known to my Lord Chatham,

Chatham, yet as some of my friends have, I should not have dedicated my book to his Lordship without having first requested them to solicit his permission: but as I considered, under the circumstances of the case, that such an application would appear to be made, with a view to make his Lordship in some measure a party in the cause, it appeared to me that the request would be attended with a manifest indelicacy. I therefore dedicated my book to his Lordship in his public character, as President of the Board of Longitude, without any attempt to obtain permission; and took care not to deceive the world, by making use of such language, as would lead them to believe, that such permission had been obtained.

Should any person, after what I have said, be of opinion, upon the perusal of this Reply, that some occasional warmth of reprehension is to be found in it, which tends to do away the effects of the apology contained in this preface: I must beg leave to urge in my own defence, that the contemptuous, and disrespectful, language, so frequently used by the Doctor himself, is a sufficient excuse for me, should I in some instances appear not to have expressed myself with as much moderation as I could have wished.

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With respect to the part of Dr. Maskelyne's answer that applies to Dr. Zach, I shall only observe, that as I really am not an astronomer, I would not do Dr. Zach so much injury, as to attempt to defend him against Dr. Maskelyne's charges. His abilities and knowledge fully qualify him to defend himself; and from what I hear, I apprehend he has not only the *power*, but the *inclination*, to do so.

As possibly some of my Readers may not have employed their thoughts much on the subject of the Longitude, and therefore may not be immediately aware in what manner Time-keepers are applied for the discovery of it, I will close this Preface with an extract from the beginning of the pamphlet Mr. Harrison wrote against Dr. Maskelyne, several years since, in which he has, in a concise, and very easy, manner, informed us in what manner the Time-keepers are made use of for this purpose.

" The Longitude of any place is its distance East, or West, from any other given place; and what we want is a method of finding out at sea, how far we are got to the Eastward, or Westward, of the place we sailed from. The application of a Time-keeper to this discovery is founded upon the following

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" prin-

" principles: The Earth's surface is divided
 " into 360 equal parts (by imaginary lines
 " drawn from North to South) which are called
 " Degrees of Longitude: and its daily revolu-
 " tion Eastward round its own axis is per-
 " formed in 24 hours; consequently in that
 " period, each of these imaginary lines, or de-
 " grees, becomes successively opposite to the
 " Sun (which makes the Noon, or precise
 " Middle of the day, at each of those degrees);
 " and it must follow, that from the time any
 " one of those lines passes the Sun, till the
 " next passes, must be just four minutes; for
 " 24 hours being divided by 360 will give
 " that quantity; so that for every degree of
 " Longitude we sail Westward, it will be Noon
 " with us four minutes the later, and for every
 " degree Eastward four minutes the sooner,
 " and so in proportion for any greater or less
 " quantity. Now, the exact time of the day at
 " the place where we are, can be ascertained
 " by well known and easy observations of the
 " Sun, if visible for a few minutes, at any
 " time, from his being ten degrees high, till
 " within an hour of Noon, or from an hour
 " after Noon, till he is only ten degrees high
 " in the Afternoon; if, therefore, at any time
 " when such observation is made, a Time-keeper
 " tells us, at the same moment, what o'clock
 " it

" it is at the place we sailed from, our Longi-
 " tude is clearly discovered. To do this, it is
 " not necessary that a watch should perform its
 " revolutions precisely in that space of time
 " which the Earth takes to perform her's; it
 " is only required that it should invariably
 " perform it in *some known time*, and then the
 " constant difference between the length of
 " the one revolution and the other, will appear
 " as so much daily gained or lost by the watch,
 " which constant gain or loss is called *the rate*
 " *of its going*, and which being added to, or
 " deducted from, the time shewn by the watch,
 " will give the true time, and consequently
 " the difference of Longitude."

it is at the same distance from the center
side is clearly discovered. To discover it is
not necessary that a water should bottom be
"revolutions" period in that space of time
which the Earth takes to perform hers. It
is only required that it should revolve
bottom in its own axis and then the
contact distance between the length of
the one revolution and the other will appear
as to much daily gained in loss of the water
which constant gain or loss is called the water
of its kind, and which being added to or
deducted from the time shown by the watch
will give the true time, and consequently
the difference of longitude.

R E P L Y, &c.

AS the Answer, which Dr. Maskelyne has published to my Narrative, has by no means decided the merits of the question, which first occasioned my appeal to the Public, relative to his trial of my Father's Time-keepers, and his subsequent conduct respecting them; I find it incumbent upon me, in order to do justice to all parties, once more to claim the indulgence of the Public, while I lay before them such observations as I have been enabled to make, in reply to what the Doctor has advanced.

But before I enter upon the task of distinctly noticing the several parts of my opponent's Answer, I feel it necessary to say something

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explanatory of the situation in which I stood, at the time I wrote the Narrative; and also in excuse of my having taken upon me to assert some few circumstances, not indeed of any real consequence with respect to the merits of my Father's case, as true, which, upon a further enquiry, do not turn out to be so.

Having had no personal employment whatever relative to my Father's Time-keepers, prior to their final rejection by the Board of Longitude, excepting that I once assisted Mr. Dutton in carrying them to Greenwich, and really never having seen any one document respecting them, until after the above event took place; when I resolved to state his case to the Public, in consequence of the opinion of a great many very respectable characters, that he had met with unfair, and improper, treatment, I found I had my whole task to learn. It cannot, therefore, be matter of wonder, that, in collecting what I deemed to be necessary information upon the subject, some things should have been stated to me as true, which, upon further enquiry, did not prove to be exactly as I have related them. But wherever I had the power of resorting to authentic documents, I did so; and the information which they afforded, except in one instance, I have faithfully given to the Public; and in that one instance, I solemnly declare,

declare, that I had no intention to mistake the fact, but upon looking again at the authority, since the publication of the Answer of the Astronomer Royal, I do find that I have not been correct. The circumstance I allude to is this; I had asserted, that the rewards offered by the Act of the 14th of his present Majesty apply equally alike to the improvement of Time-keepers, and of the Solar and Lunar Tables, which I find not to be the case; but that a separate sum of 5000 l. is offered for the improvement of the Tables. I was led into this mistake, however, by the Act of Queen Anne, which proposes one set of rewards for *all* the different methods by which the Longitude may be discovered, not being aware that the Act of his present Majesty, which I did not happen to look over, with a view to that particular question, had made a distinction, which was not contained in the former Act; and when it is considered, that the separate sum, offered for the improvement of the Tables, is inserted subsequent to all the directions given relative to the Time-keepers, which are not very short, I trust it will readily be believed, that my misrepresentation was not a wilful one, but the effect of a mere oversight.

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I shall only add, that with respect to any other circumstance, which, upon investigation may not appear to be precisely as I have stated it, I most seriously declare, that every thing I have asserted to be fact, I really believed to be so at the time I wrote it; and as those particulars, which materially tend to impeach the conduct of the Astronomer Royal, will, in the course of this Reply, be still insisted upon to be true; though I should have been much better pleased, if every trifling circumstance mentioned in my Narrative would have stood the test of the most rigorous examination, yet some few things of this kind, turning out to be the effect of misinformation, will neither justify Dr. Maskelyne, nor derogate from the justice of my Father's complaint.

I will beg leave also to say something in answer to what the Doctor asserts, as to his belief respecting the part he supposes my Father to have taken in the writing of the Narrative. He tells us, that he supposes my book was written by the direction and advice of my Father; and therefore he shall consider what I say, as equally coming from him. Now the fact is, that I neither wrote the book under his direction, nor by his advice; and though it be true, that he knew I was writing it, yet he did not afford me any other materials, than such, as I by frequently

quently talking to him about his Time-keepers, in a manner extorted from him: for the conscious dignity of injured merit operated so strongly upon his mind, that he was not of himself disposed to be communicative upon the subject, even to his son; and he did not actually see the contents of the book, until after it was printed, nor has even now read the whole of it. Were it true, that I was more the agent of my Father in writing the pamphlet, than the actual author of it, the Doctor might be at liberty to say my Father had not kept his word; for I have been told by him, since I undertook the unpleasant task of asserting his claims, and defending his reputation, that he was once questioned by Dr. Maskelyne, whether he intended to follow the example of Mr. Harrison, and write against him; when my Father assured him, that whatever might be the fate of his Time-keepers, he certainly should not.

As I have now said something, in a general way, of the situation in which I stood, when I resolved to become the champion of my Father's cause, and, in defiance of the frowns of the Astronomer Royal, to shew the public, that his merits were of a very different nature, from what the Doctor had thought proper to represent them, I will proceed to reply to what the Doctor has advanced in his own justification; and I

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hope I shall be able to make it appear very clearly, that, notwithstanding all he has said, the strong, and substantial, facts, which I have urged in my Narrative, as proofs of the goodness of my Father's case, and of the unfairness of the Doctor's conduct, are not either overthrown, or impeached.

One of the first circumstances to be noticed is this, that though I expressly charged the Professors, who were members of the Board of Longitude when the Act of the 14th of Geo. the Third passed the House of Commons, with wishing to shut out the mechanics entirely from all the benefits to be derived from it, and stated that Dr. Maskelyne afterwards made use of language, in speaking of the Act, which shewed in very strong terms, that its operation would most effectually prevent their getting the rewards offered by it; yet the Doctor passes over these circumstances in silence, and leaves them wholly uncontroverted. But he, nevertheless, with what degree of consistency the readers will judge, strongly insists upon it, that, so far from being an enemy to mechanics, he has been one of their best friends.

With respect to the act itself, it may be necessary to say, that it affected my Father in a manner peculiarly hard, and that for the following reasons: When he retired from business

ness in 1771, with an intention to exert his abilities in the improvement of Time-keepers for the discovery of the Longitude at sea, the Act of the 12th of Queen Anne, with respect to some of the rewards, was considered to be still in force; and besides, that the strictness of the limits, prescribed by that Act, was not one fourth part as great, the various clauses, that were to regulate the trials, were by no means so severe, nor was the discretion of the Commissioners, as to the continuing such trials, so extensive, as in the latter Act. Indeed, as to the latter, there being no limitation for the voyages, which the Commissioners may think proper to send the Time-keepers, were Time-keepers invented, that, during a course of twenty years trial, should be found to come within the limits, still if the Commissioners should choose to express themselves not satisfied, the Act gives the inventor no power to claim the reward, but leaves him entirely without remedy. By the Act of Queen Anne the rewards were to be paid, one moiety, when the Commissioners, or the *major* part of them, should agree, that the method invented for discovering the Longitude extended to the security of ships within eighty geographical miles of the shores which are places of the greatest danger; and the other moiety, when a

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ship,

ship, by the appointment of the Commissioners, or the *major* part of them, should thereby actually sail over the ocean, from Great Britain, to any such port in the West Indies, as the Commissioners, or the *major* part of them, should chuse for the experiment, without losing the Longitude beyond the limits therein mentioned. And not only were the rewards greater, and the terms for obtaining them much more easy, than by the present Act; but, as the reader will observe, they were to be awarded upon a determination made by the *major* part of the Commissioners: whereas, no candidate can obtain the rewards proposed by the present Act, unless *two-thirds* of the Commissioners shall declare in his favour. As therefore the Professors shewed themselves averse to admitting the mechanics to be at all objects for the specific rewards of the present Act; and they can at any time form such a number, when they chuse to unite their forces, as will prevent the rest of the Commissioners, who usually attend, from making two-thirds of the whole, even though they should all agree; it will, I believe, be thought, while they continue averse to the success of Time-keepers, that, setting aside the extreme, and, in the opinion of many skilful scientific men, unnecessary, exactness, which the act requires, the
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mere regulation, that it shall be necessary for *two-thirds* of the Commissioners to agree, in order to vest the right to any of the rewards in a candidate, would, in effect, though not in words, preclude any person who should make Time-keepers, that should go within the limits of the Act, from reaping any of the benefits it holds forth *.

But to return to the hardship that particularly applied to my Father. When he began his labours, he not only considered himself as entitled to claim the unapplied rewards of the Act of Queen Anne, in case the Time-keepers, he might make, should accomplish what it required; but he had reason to promise himself the full benefit of it, during the whole three years he was employed in making his first Time-keeper; as it was not until that Time-keeper was completed, and ready for trial, that the present Act passed: and I am firmly per-

* Since the publication of my Narrative, Mr. Arnold has called at Mr. Dutton's, and told him, that he was ready on my behalf, if necessary, to come forward, and swear, that he heard Dr. Shepherd once, in the presence of himself and his wife, say, that it was never the intention of the Board of Longitude, that Time-keepers should succeed; which strongly corroborates what I mentioned in the Narrative, as having been communicated to my Father by the late Sir John Pringle.

suaded,

suaded, that had that Act been in existence, when he first began his undertaking for the improvement of Time-keepers, with a view to the public rewards offered for them, he would have totally given up his scheme. What his opinion of the Act was, his conduct at the time he brought his Time-keeper to London to be tried, most strongly shews; for, finding that the present Act had been framed, and was then passing, he immediately applied to his friends to assist him in shewing to the Legislature, what great objections there were to the extreme severity, and strictness, of the clauses: and he actually applied to the then Speaker of the House of Commons (Sir Fletcher Norton) at his house in Lincoln's Inn Fields, and fully expressed his mind to him upon the subject. Sir Fletcher promised him, that he would make the necessary enquiries, and see what could be done to give him relief; and it appears by one of the minutes of the Board, dated 27th May 1775, which Dr. Maskelyne gives in his Appendix, that the Speaker remembered the circumstance, and, some time after, actually informed them, that my Father had several objections to make to the Act. Besides applying to the Speaker, my Father also went, he thinks it was with Mr. Stephens, and the late Sir Gilbert Elliot, to the House of Commons,

Commons, to see, as the Act was not actually completed, whether it was possible to take any steps to oppose it; when he was informed, that it was gone too far, having been read three times, and the blanks having been filled up. I think, under these circumstances, that my Father must be allowed to have been extremely unfortunate; for whatever doubts may remain, whether he has strictly entitled himself to the rewards of the 14th Geo. III. yet there can be no doubt entertained, that the excellence of his Time-keeper would have long since entitled him to the greatest reward offered by the Act of Queen Anne; which in fact he has been deprived of by a law, that, considering the circumstances attending it, was, as it affected him, not very unlike in its nature to an *ex post facto* law.

I will now proceed to consider Dr. Maskelyne's defence of himself, and the arguments he makes use of to justify the methods he has adopted in the course of his proceedings. The first circumstance I shall notice, is the stopping of the first Time-keeper on the 10th of February 1775, which the Doctor pretends to deny having been occasioned by any misconduct in himself; and as to the letter, which I have stated to have been written by him upon the occasion to Mr. Dutton, he says,

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he apprehends Mr. Dutton has applied to the first stopping, the information he gave him relative to the second stopping three weeks afterwards by the breaking of the main spring. The Doctor himself admits, that Mr. Dutton, when he came to Greenwich, attributed the stopping to the carrying backwards and forwards from the Great Room, which he could not possibly have done, if it had arisen from the breaking of the spring; for then he could not have set it in motion again, till the spring had been replaced; but laying this out of the question, still he does not account for the misrepresentation contained in the letter, in stating the Time-keeper to have stopped at one time, when, in fact, it stopped at another, which affords a strong argument that the Doctor had something to conceal.

Though I admit, that the letter has been either lost, or destroyed; yet I think I can very satisfactorily convince the world, that such a letter was written, and at the very time we are now speaking of. First, Mr. Dutton would swear, if called upon, that he received such a letter; and, secondly, Count Bruhl, who has also seen it, has told me that he should be equally ready to swear to the contents of it, which he perfectly remembers to have been, as I have stated them; and, with respect to the
time

time when it was written, I think the following copy of a letter from my Father to Mr. Dutton, written on the 3d of March, which is twenty-one days after the first stopping of the Time-keeper, and ten days before the second, in which he particularly notices the circumstance, will sufficiently ascertain the exact time to which the Doctor's letter to Mr. Dutton must have referred. As the letter has not much in it upon any other subject, I will insert the whole of it.

" DEAR SIR,

" I received yours of the 25th of February. It was taken up at the office by my brother, and did not come to my hands till it was too late to answer it by return of the post: however, it was no disappointment, as I should not have given you any particular instructions for your conduct at the Board of Longitude, nor even have desired you to attend, unless curiosity had carried you there: I am ashamed to have given you so much trouble as you have already taken about it, especially as I am fully persuaded it will not answer any good purpose; and I believe you, and every body else that reads the Act, and knows M——'s conduct, will believe the same. I shall resume this subject again before I have done; in the

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mean time; lest I should forget it, I shall say a few words with relation to Lord Kerry's affair. You say you did not know till you waited upon him, whether I had answered his letter: I don't know whether or not he has ever wrote to me, but I assure you, upon my word and honor, I have never received any from him; and if he has wrote, I fear he will think me a very ill-mannered fellow to take no notice of it, in which you will please to set him right when he calls upon you again. I sent away Count B.'s clock last week; and I make no doubt, but 'tis come to hand before this time. I did not advise you of it, as I had no frank, and did not chuse to put you to an expence merely upon that account, I therefore desired Count B. to acquaint you of it. Now to Mr. Ast—er R—l again. I must confess, as so many objections were at first made to his absurd design of keeping the watch in the Great Room, I thought he would, for his own credit, have taken the greatest care that it was not stopped by his carelessness; but I find he has a salvo for that, for to excuse his own carelessness, and bad conduct, he throws the fault upon the watch, and tells you a downright falsity, and says it stopped three hours after it was observed; whereas it appears by your questioning his assistant, that it stopped in carrying

rying up stairs, which was but nine or ten minutes after the observation; but the stopping is not all that is to be found fault with, the errors in the going appear to be three times greater than either you or I ever found in it, and are probably in a great measure owing to the same cause; for one half of the motion that is necessary to stop it, will make it hit the banking; and how much a watch may be accelerated by hitting the banking pretty smartly two or three times, you can guess as well as I. There is one thing in the register of the going of the watch, that I can't help taking notice of, as it appears to me very extraordinary; it is this, that the thermometer has at no time since the 15th of December been lower than 33. When Mr. Harrison's was tried, which was kept in the Transit Room, it was so low as 25½, and yet Mr. Maskelyne says that the Great Room is hotter and colder by 10 degrees, and gave that as a reason for keeping the watches there; the winter indeed has not been very severe, but we have had some very cold days, and even in this warm country some have been lost in the snow. If any thing interesting relative to it should be said at the Board of Longitude — I take it for granted you will let me know it when you write next; but if only tittle tattle, it wont be worth taking

notice of. But before I have done, pray let me ask you one question, Did Mr. M. tell you when you was at dinner with him that it stopped three hours after observing, or did he say so in the letter which he wrote to you? If he said so in the letter, I should be obliged to you if you would take care and preserve it, it may possibly be of use. I had some intentions of making some alterations in it, which I think would be a considerable improvement, and rid it probably of at least half its present errors, and had purposed to have brought some of it to London with me this summer, to get that done there, which I can't do myself here; but I now give it up as I plainly see it will be to no purpose. I think my time will be employed more to my own advantage in mending my wooden cuckoo clock, that the maid may have no pretence for spoiling my dinner."

"Thus much for this affair, I shall only add, that I shall very soon (I have not yet fix'd the time) trouble you with another draft, my cash being almost gone, which I thought to have made hold out a little longer by the help of the money for the chain; but there are two words to that bargain, the gentleman is gone to town, and has not paid me; however the money is very safe though long a coming. I
am,

am, my dear Sir, with best wishes to yourself
and family,

Yours, most affectionately,

THOMAS MUDGE.*

* As I have been favor'd by his excellency Count Bruhl and Mr. Dutton with several letters which they received from my Father in the course of his employment about his Time-keepers, and which contain not only many ingenious and satisfactory reasons for many circumstances that took place relative to the Time-keepers, but also such very noble, and liberal, sentiments, as shew, that so far from being an interested watchmaker, he discovered himself to be an ingenious and candid artist, influenced at all times by the most honorable sentiments; I shall occasionally, as the circumstances I have to relate will warrant it, give either copies, or extracts, of such letters. And I believe it will be likely to happen, that the world, so far from giving credit to Dr. Maskelyne in the character he ascribes to my Father, will be rather inclined to turn the tables upon him, and instead of thinking my Father an interested watchmaker, will suspect the Doctor has proved himself a prejudiced astronomer. Indeed in one letter, which my Father wrote to Mr. Dutton in November 1777, there is the following passage, by which it will appear, that he was actuated by the strictest impartiality, though to his own prejudice. "In Mr. Maskelyne's register, which you have been so good as to send me, I find the errors somewhat greater than in the last four months register, where the greatest error in any two days was, 1",3, whereas in this it is 1",6; I am not much afraid that Mr. Harrison's will go much better, *if it should, I think the Commissioners should give the preference to it;* though I must confess, as 'tis professedly his Father's, except the simplifying, he will have very little pretence to any premium, notwithstanding his Father thought himself rewarded in so niggardly a manner."

I shall

I shall now advert to the misrepresentation the Doctor charges me with, relative to the carrying of the Time-keeper backwards and forwards, and up and down stairs; and I trust shall shew most clearly, that if from misinformation, not having been acquainted with the situation of the different parts of the Observatory myself, I have been mistaken with respect to the number of stairs, which is only one circumstance in the business, the Doctor, though he must be necessarily acquainted with every thing belonging to the Observatory, has been guilty of much greater misrepresentation on his part relative to the same transaction. I had stated in my Narrative, that the first Time-keeper, instead of being kept in the room where the clock was, with which it was to be compared, was kept in a room on the other side of a court, across which, and up two pair of stairs, some of them so steep as to resemble a ladder, it was daily carried for the purpose of observing its variation from the clock. This the Doctor expressly denies to be fact, and uses the following language, p. 30 and 59: "I kept it in the Great Room, only one easy pair of stairs *above* the Transit Room;" and afterwards says, "it was necessary, in consequence, to carry the watch *down* the easy pair of stairs before mentioned, every day

day about noon, to the Transit Room to compare it, after winding it up, with the Transit Clock, and to carry it back again the same way as it was brought *down*, and deposit it in the Great Room till the next day." Now I think it very likely, that his readers will believe from this account of the matter, that the Great Room is *over* the Transit Room: and will perhaps be a little surprised, when they are informed, that it does not constitute a part of the same building; but is actually placed on the other side of a court, which it is necessary to cross in the open air to go from the one to the other, in doing which some steps must be descended which are placed there on account of one part of the court being lower than the rest: and the stairs themselves leading to the Great Room, though not two pair, as I had always been told, are by no means an easy pair of stairs, as the Doctor represents them. The situation of these places is too well known not to occasion my being immediately detected, if my description of them is wrong.

Upon talking since to my Father, about the place where the Time-keeper was kept in the Great Room, he has told me, he understood it was upon a shelf, and that it was necessary always to use some steps in putting it up, and taking it down. And with respect to what the

the Doctor says, about the propriety of carrying it backwards and forwards, what my Father observes in the foregoing letter will shew very strongly, why it ought not to have been done : in addition to which Mr. Dutton informs me, that while it was treated in this manner, he, one day, speaking to Dr. Shepherd about it, urged to him the great impropriety of doing it, on the score that its going might be either retarded, or accelerated, by a quick and improper horizontal motion being given to it in a direction contrary to the vibration of the balance ; adding, that if the Doctor pleased, he might actually stop it by such treatment. As a further proof, that my Father had much to apprehend, from its being carried up and down stairs, and across a court, in the manner above mentioned ; and that he had no reason to expect, that it would be handled very gently, or treated with much care, by the Doctor, I shall transcribe a few lines from Mr. Harrison's book, p. 22, where, after having stated his having delivered up one of his watches, upon receiving a certificate for the first moiety of the reward, he goes on thus : —“ The other three machines were (by order
 “ of the Commissioners) soon after demanded
 “ of me by Dr. Maskelyne. One of them,
 “ which had been going more than *thirty*
 “ years,

“ years, was broke to pieces *under his careful*
 “ *and ingenious management* before it got out of
 “ my house; and the other two were so far
 “ abused in the carriage by land to Green-
 “ wich, as to be rendered quite incorrect, and,
 “ as far as I can learn, incapable of being
 “ repaired, without having some essential parts
 “ made anew. Thus perished the first essays
 “ of this long-wished for invention.”

The Doctor says, p. 60, “ That he very
 much questions whether the stopping of the
 watch arose from carrying it to and fro be-
 tween the Transit and Great Rooms, as *I have*
alledged ;”—and “ that he does not think that
 a person going up stairs *can* make sudden and
 quick turns sufficient to stop the watch, and
 much less when he proceeds with caution, as
 he would naturally do in a case of this kind.”
 After the passage I have quoted from Mr.
 Harrison, the reader will not be inclined to
 attribute much to the caution the Doctor was
 likely to observe; and when he considers that
 the watch, in consequence of being placed in
 the Great Room, was obliged to be carried to
 and fro in the open air once every day during
 a space of fifteen months, he will perhaps
 think, that when it rained hard at such times,
 which, in the course of so long a period, it
 must frequently have done, the Doctor, or his
 assistant, would be much disposed to *accelerate*

his motion, though the Time-keeper did not, in a manner not perfectly consistent with the caution he pretends to have observed: and if it was impossible he could have made sudden and quick turns sufficient to have stopped it, in going up stairs, it only proves, that the stairs were not so very ample and commodious as he would wish to have it believed; but by no means shews, that there was not room enough in the court to have made such motions before he began to ascend; or that they could not have been performed with ease either in the Great Room or Transit Room. Besides, had the Time-keeper in the daily carriage of it backwards and forwards, under the circumstances above stated, happened to have been let fall upon the stones of the court, an accident to which it was certainly by this treatment exposed, it would have been entirely destroyed; and being a new invention, and the only machine upon the same principles then in existence, its destruction would not only have been a great injury to my Father, but possibly might have been considered as a loss to the Public.

With respect to the question, which the Doctor asks, p. 61, "Whether, if it should be allowed, that the Time-keeper stopped from this cause, I do not say the worst thing I could
of

of it, and what no other maker of Time-keepers would allow to be said of theirs, that it is not fit, or too delicate, to bear motions which it must necessarily be subjected to, in removing from one place to another, by putting into, and taking out of, post-chaises and boats, and carrying up and down the sides of a ship, which are indeed steeper than any ladder, though the stairs at the Royal Observatory are not, and how, in that case, it will bear the shocks of some seas, which strike a ship on the quarter, and will give the watch a violent motion in the plane of the balance?" I answer, first, that I never said it was unfit, or too delicate, to bear the motions it must necessarily be put to in any of the instances the Doctor mentions; but expressly said, p. 7, that the accident of their stopping could never happen to them from any motion communicated by a ship at sea, or from any other cause of a like kind, except their being *violently* and *wilfully* moved in a circular horizontal direction; and, secondly, that the Time-keeper in question has actually been exposed to *all* the different kinds of motion, which the Doctor has enumerated, without having been ever stopped by any of them in any other hands than his own. It has been carried, for instance, two voyages to Newfoundland by Ad-

miral Campbell, as I have already stated in my Narrative, in the course of which it must necessarily have been carried up and down the sides of the ship several times; it has also travelled both by land and sea many thousand miles, in the hands of Count Bruhl, Dr. Zach, my father, and Mr. Dutton; and when travelling by land was either carried on the seat of a post-chaise, or on that of a stage-coach.

In its passage home from Newfoundland, in both voyages, it must have been exposed to many of those shocks of the sea, which strike a ship upon the quarter, of which the Doctor speaks; for as the time of returning from that station is generally a little after the autumnal equinox, the weather is usually turbulent and stormy. In fact, though it is now more than 14 years since the Doctor's trial of it, during which it has been constantly going, it has never stopped once during all that time, *without* an apparent cause; and but once *with* one, which was in the interval between the two Newfoundland voyages, when the spring broke.

I will here take notice of the breaking of three main springs, belonging to this Time-keeper, from the time it was first made; for though Dr. Maskelyne admits, that the breaking of a main-spring, as it is an accident that
all

all watches are liable to, is not to be considered as a particular defect in any ; yet as a very satisfactory reason can be assigned for its having happened so often with the *first* Time-keeper, and not once with either of the others, and now not for eight years with that, I will state what that reason was. The first Time-keeper, instead of being constructed to go only a single day, as they are usually made, was furnished with a spring, large enough to make it go a week ; but, though so contrived, it was wound up every day, by which means the spring was constantly kept in a state of almost as great tension as it would admit of, and was not suffered, as other springs are after they are wound up, to run nearly down, and then be wound up again, whereby the great degrees of tension given to them bear but a small proportion to the whole time their force is employed ; consequently the probability of their breaking is considerably less than when they are always strained nearly as much as they will bear. After it had broke a third time, my father put a stop upon it, in order to prevent it from being wound up further than would occasion its going about two days, and in consequence of that alteration, no great degree of tension having been since given to it, the Time-keeper has now gone with the same spring for about

eight

eight years without its breaking at all : and indeed from so small a strain being given to it at present, by reason of its never being wound up more than about one third, it is less liable to break than springs in general.

On asking my Father, why he put into his Time-keeper a spring so large, as to enable it to go a week, he told me, that his reason for doing so, was not because he thought he thereby made it better as a marine machine, but that he wished to try an experiment ; whether, by a particular contrivance, he could not make a machine for measuring time, with a spring which should keep it in motion for a week, go as well as machines, or watches, the springs of which would enable them only to go a day ; which he informed me had not always been found to be the case. How far he was successful in his experiment, the goodness of the Time-keeper has since pretty well proved.

To return to the stopping of the Time-keeper, I observe, that though it appears in the minute given by the Doctor from his own register, that Mr. Dutton ascribed it to the carrying from room to room, yet it was continued to be carried to and fro in the same manner till the 27th of May following ; when it appears, according to the Doctor's own shewing,

shewing, that upon my Father's attending to object to the above mode of treating it, it was ordered in future to be kept in the Transit Room only : so that though Dr. M. so often boasts of having always been my Father's friend, it is plain, that upon this occasion he was actuated by principles of a very different kind, having persisted in doing what my Father and his friends considered to be most unfair conduct, until the authority of the Board of Longitude was called in to prevent him. Nor can the circumstance of the 500l. given to my Father to enable him to pursue his labours, which the Doctor wishes to have considered, as not only having been sanctioned, but jointly proposed, by himself and Dr. Shepherd, be deemed any proof of his good inclinations ; for I believe the fact would turn out to be, that having perceived he had excited much displeasure in the minds of my Father and his friends by his improper treatment of the Time-keeper, he was desirous of procuring the 500l. for him, in order to heal the wound he had occasioned, and prevent further enquiry.

I may also make another reflection, which the perusal of the minute given by the Doctor suggests to me, which is, that though he tells us the reason, why he considered it proper to keep the watch in the Great Room, was on account

account of an observation he recollected my Father to have made respecting Mr. Harrison's watch, yet it appears, from the minute itself, that Mr. Kendall's watch, which was tried after Mr. Harrison's, was not kept in the Great Room, and carried backwards and forwards, as my Father's was. And besides Mr. Kendall's Time-keepers, the language of the minute would lead me to apprehend, that all other Time-keepers, which had been under trial at the Observatory, whether those of Mr. Harrison, Mr. Kendall, or Mr. Arnold, were tried in the Transit Room. And why my Father's should be singled out to be tried in a different manner from all others, contrary to his own and his friends inclinations, is neither very easy to be accounted for, nor very consistent with the Doctor's pretended friendship for him. As to the reason which the Doctor assigns for this conduct (viz. that he should get a greater degree of heat and cold), that is, in my opinion, sufficiently exposed by the contents of my Father's letter, of which I have already given a copy. But I will further add, that though my Father was of opinion, that Time-keepers, while under trial, should be exposed to sufficient degrees of heat and cold, and was very ready that this should be the case with respect to his own; yet this does not prove,

prove, that he ever thought it would be right to carry them every day up and down stairs, and to and fro in the open air, and thereby subject them to many accidents, and much irregular motion, in the manner before stated; nor by any means shew that such treatment was, in his opinion, proper.

This circumstance, being now fairly before the Public by the accounts given of it by both parties, I must leave it to them to form a judgment respecting it, and shall proceed to take notice of a curious observation, which the Doctor makes, p. 43, relative to the stopping of the two last Time-keepers. His words are, "had I been ill inclined to the watches, as Mr. Mudge insinuates, I should have made no remark at all to explain the cause of their stopping." Now I think it evident, that any person, who was not ill inclined to the Time-keepers, would upon their stopping in consequence of his having neglected to wind them up, which was the case with the Doctor, have thought it incumbent upon him to have stated candidly, that they had stopped for want of winding up; and not have left the world to suppose, by his merely saying they had stopped, and disingenuously omitting to state the reason, that the stopping had been occasioned by some defect in the Time-keepers, when it was really the ef-

fect of his own negligence. To shew, however, that the Doctor once actually did use such language, as he tells us might have been expected from him, if in fact he had been an enemy to the success of the Time-keepers, I shall relate the following circumstance. While this Time-keeper was under trial by Dr. Maskelyne, it was much Mr. Dutton's practice, after any Board of Longitude, to call upon one of the members, with whom he was acquainted, to enquire what report the Doctor had given of it; and upon doing so immediately after the Board that succeeded the stopping, he was informed by the member he waited upon, that the Doctor had told the Board, the Time-keeper had stopped. What, said Mr. Dutton, did he not tell the Board the reason of its stopping? To which he was answered, That the Doctor had said nothing more of it than that it had stopped.

Dr. Maskelyne mentions, p. 34, another stopping of the watch in February 1778. Now here in fact it did stop from there being something amiss with the watch itself, and I think it a circumstance not a little strong in confirmation of this not having been the case upon the first stopping, *three years* before, that by the following letters written by my Father it will appear, that when he heard of the stopping

ping this time, he immediately allowed it had happened from something amiss in the watch; and it will be found, that he began to reason upon, and endeavour to discover, the cause of it, before the watch was sent down to him at Plymouth. If my filial attachment to my Father does not very much warp my judgment, I cannot help thinking the following letters will not only shew him to be a man capable of reasoning ingeniously; but will also make it appear, that he has always been liberal and candid in the opinions he has formed. The stopping of the watch appears, by Dr. Maskelyne's account, to have been on the 16th of February, and the first of my Father's letters, in point of date, is written on the 3d of March following to his Excellency Count Bruhl. The reader will distinguish this letter from the one written on the same day of the month three years before, and will observe, that at the time of writing it my Father had not seen the watch; but only reasoned upon the circumstances of its stopping from what he had heard from his friends in town. The letter is as follows.

"DEAR SIR,

"I had the honor of your's of the 23d of last month, and am sorry for the occasion of your writing it; and should be equally sorry

to be deprived of the pleasure of hearing from you, on the score of my time being fully employed, whenever your leisure or inclination will permit you to do me that honor. I cannot acquiesce in the reason that you give for the watch's stopping; the breaking of the spring that keeps it going while winding up could not stop it, if it were so, it would only lose somewhat of its time, and that immediately at the time of winding up, which I think Mr. Maskelyne must at some time or other have observed. I don't well understand what you mean by saying, that, "if the difference between the two quantities mentioned in the inclosed slip of paper corresponds with the sum total of its gain since it was carried to Greenwich, there is great reason to believe that that was the cause of its stopping." I must confess I don't at present see what relation they bear to each other. It does not appear from your letter, whether Mr. Dutton found the watch stopping, or whether it had been set agoing before he came; or whether it had stopp'd for that interval of time, and then went on again of itself; I don't mention this, as at all suspecting any unfair play from the Doctor or his assistant; I am too well persuaded it arises from a fault in the watch, a fault that I was not totally unapprized of, and
which

which I fear will reflect upon me for negligence in not remedying it ; but it wont be without its use, as it enables me very naturally to account for its acceleration ; all I fear is that it may leave an ill impression on the minds of those, that I would not wish to be prejudiced against it. The fault of it I suppose to be this, that the balance wheel pinion is rather too big, and the contrate wheel rather too shallow in it, which has occasioned it to stop ; I had observed about two years since when I was at Mr. Dutton's, and took the cock off in order to have it gilt, that, upon setting it agoing again, the balance wheel faultered ; and as I could not then and there take it to pieces, I put a little oil to the pinion, hoping that that might prevent it ; now as I am very well persuaded it has *stopp'd* from that cause, it is very reasonable to suppose, that it frequently loses so much of its force as not completely to wind up the small springs ; the consequence of which will be that the arc of the balance will be lessen'd (and by Mr. Dutton's observation is lessen'd full eight degrees), and if the smaller arcs are quicker than the large ones, it will consequently go faster, and that irregularly too ; you may remember I told you some time since, that I was by no means satisfied with the method I had taken to determine that matter ; that this is the
real

real cause of its stopping I am fully persuaded, and indeed I before so far suspected the possibility of it, that I have made the pinions of my present watches less, though the contrate wheels are of the same size. I should be sorry that metals should have the properties you suggest, that of altering their magnitude by an encrease of heat and not returning to the same size when the heat returned to the same degree; for that would put an immediate stop to all further hopes of improvement, both on the score of the balance as well as the Thermometer; the latter of which I have myself sometimes suspected did not return to the point it ought to do immediately after having been heated to an uncommon degree (which has not been the case here), but that I did not attribute to the alteration of the heat not having its due effect upon the metals, but to the friction between the two metals, though after all I have some small doubt whether it is a fact or not.

“ I sincerely condole with your Excellency on the loss of your Brother, and I feel it the more sensibly, as I have myself also an only Brother, who is so exceedingly tender, and so miserably harassed with the gout, that I am frequently under great apprehensions for his life. I hope you will be so good to let me know
before

before you set out for Germany, as I would not willingly be in London when you are absent, and it will be rather late in the year before I shall be able to come, if I bring the watches with me, which is my present intention.

I am, Sir,

Your Excellency's most obliged,

And obedient humble Servant,

THO^s. MUDGE."

The next is part of a Letter to Mr. Dutton, written on the 31st March, when the watch was in Mr. Dutton's possession; and is as follows:

" DEAR SIR,

" You have, I suppose, by this time tried the experiment with my watch, which I desired you, and I make no doubt but you have found the effect that I expected, at least in some degree; for that it should perfectly remedy the evil, is not to be expected, as it must by this time (between two and three years) have contracted some foulness; 'tis some satisfaction that it is not an error from principle (for that I am convinced it is not) but such a one as every watch, or clock, be the mode of making

making it what it will, is equally liable to, and may be always avoided by proper care and attention: I must confess 'tis somewhat surprising to me, considering that, from the appearances mentioned by the Doctor, as well as those taken notice of by yourself, it must very frequently have halted, and been near stopping (though it did not absolutely stop), that the error in its going should be so small as it is, and I think is a strong proof of the excellence of the *contrivance*, or what is generally called the *principle*.

"I have not yet finished either of the new ones, though one of them is so near it, that I expected it would have been done to-day, if this writing had not prevented it; it is adjusted in every particular, as near as I think I can do it, and is now partly cleaned, in order to its being put together for the last time, I hope. It is not in every respect what I could wish, and it has some faults, that are the consequence of too much care; 'tis a paradox, but I am convinced of the truth of it: I shall be heartily glad when the other is as forward, for I am quite tired of them; but I am now tied to the stake, and must see it out.

Dear Sir, I remain,

Yours, &c.

THO^S. MUDGE."

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The next is a letter written to Count Bruhl, and dated the 1st of May following, by which time the watch had been sent to my father at Plymouth, and he had examined it, so as to know with greater certainty, what actually were the causes of its stopping. The following is a copy of this letter :

“ DEAR SIR,

“ I received your Excellency's favour of the 11th instant, and am much obliged to you for the many kind expressions in my favour. I wish I knew how to deserve them. In consequence of the note you was so kind to send to Mr. Dutton, I have since received my watch, which, on trial, I found would not go at all, and feared I should have some difficulty to make it go till it was down ; but on taking it out of the case, and examining it, I soon got over that difficulty. I found the second wheel apparently tight, and I had some doubt whether there was not some rust round the pivot, and a languor in the force from the other wheels also, proceeding from the thickness of the oil ; however, that was not sufficient to have stopped it, nor do I apprehend that it was the contrate wheel, where I suspected it, though that might probably have a share in it also. The principal reason of its

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stopping

stopping was, the want of oil to the balance wheel teeth, where I had originally put but very little (and that I believe not very good, as I had had it full two years before I used it to the watch); for I put oil there, not because I thought it necessary to its going, but by way of preservation; but in the course of making my new ones, I found sufficient reason to believe it quite necessary, and it happens fortunately, that the figure of the pallets is such, as will retain a sufficient quantity, without its running away to parts where I would not chuse it: what is to me at present the most unaccountable, is its rate of going; since I put oil to the teeth of the wheel, it appears to go on as well as it did at first, and the vibrations of the balance are but a few degrees less, but it goes about 10" a-day too fast, which I know not at present how to account for, as I cannot suggest any consequence, from length of time, that would not make it go rather slower than faster; but the examining more accurately into it, must be left till I have time to take it to pieces, which will not be till the winter.

“ Agreeable to my promise, I enclose to you a register of the going of the new watch, by which you will see, that from its being first set agoing, it went for some time slower and slower,

flower, a circumstance we may naturally expect; for as we know by experience, that springs kept constantly tense will lose some of their elastic force, so we may reasonably expect, that the balance springs, by being constantly bent backward and forward (though not in a constant state of tension), will lose somewhat of theirs also, though in a less degree; it is experience only will enable us to judge what to allow for that, and how long it will be before the force becomes permanent: from about the 10th of April downwards, the errors seem in a good measure to correspond with the rise and fall of the thermometer, though I have sometimes a doubt with myself whether there has not some small error crept in from another cause, which I intend as soon as the other is set a-going, to put out of doubt, by taking out the balance, and altering the part I suspect to be faulty; I had done it before now, but that I was obliged by illness to lie by for full a fortnight after I wrote you last; but I have now, I hope, perfectly got rid of my disorder, and the watch is so forward, that I shall put it together in order to its adjustment to-morrow, or on Monday next.

“As I suppose your Excellency is just upon setting off for Saxony, and that this will be

the last time I shall have the honour of writing to you till your return, permit me to wish you health, and a pleasant tour; though it seems, from the papers, as if you was likely to meet with as much confusion in the country you are going to, as we have had in this for some time past *.

I am, Sir,

Your Excellency's most obliged,

And obedient humble Servant,

THOMAS MUDGE."

May 1, 1778.

As I am now about to reply to the Doctor, as to the several instances he has produced of the going of the Time-keepers, and the conclusions he has drawn from them, I will first venture to make some further observations respecting the proper methods of ascertaining rates, and what I still conceive to be

* Do these letters contain the unqualified assertions of a man who, upon finding an error to have been discovered in a thing which he had represented to possess great perfection, immediately declares the error to be nothing at all—that he can get rid of it at once, and shew the thing to be perfection itself? Are they not rather the candid ideas of a man, who shews himself conscious of his powers, and therefore feels an assurance, under the circumstances of the case, that he can easily remove the seeming errors of the machine.

the

the proper and fair modes of comparison ; and will then proceed to animadvert, if not on all, at least on all the most material, circumstances, which he urges, to shew, that my Father's Time-keepers have not gone with a sufficient degree of correctness to entitle him to any of the rewards he has applied for ; and I do this the rather now, that I may, if possible, before I particularly notice the instances which offer themselves to me, as proofs of Dr. Maskelyne's disingenuous conduct, endeavour to remove any improper bias, which his specious and plausible way of reasoning may have impressed upon the minds of my readers.

Upon the perusal of Dr. Maskelyne's answer, and a reference to his register from day to day, which I have printed at the end of my Narrative, I was particularly struck with the great difference in the apparent errors of the Time-keepers between the first six months, and the last ; and as in the instances he notices where he has applied a rate, deduced from the going of the Time-keepers during the first month, to the whole of the time afterwards, the errors of the last six months are very much greater than those of the first, it occurred to me, that this might be a means of shewing the unfairness of the rate itself, by making it appear that the quantity of error will almost always increase

increase in proportion to the distance of the period, out of which the rate is taken, from that to which it is applied; and it might also shew how fallacious the Doctor's method of determining the true excellence of Time-keepers is, by proving, that upon a comparison of the results, with those given by other rules of judgment, which the Doctor himself has not denied the justice of, they do not at all quadrate; but frequently, when by the application of the method to which the Doctor seems so much attached, the error turns out to be very great, by using the other methods there appears to be a great degree of excellence.

To exemplify this mode of reasoning, I shall compare the errors of the Time-keepers in each successive month, as indicated by the Doctor's rate, taken from the first month of the trial, with their errors in each month, as found by a rate taken from the month immediately preceding it; and then shew, that with the Doctor's rate, the sum of the errors of the last months of the time are disproportionably greater than those of the first; but that, with the rate deduced from each preceding month, the difference is very trifling: which I think will be a strong argument among many others, to prove the absurdity of using a rate taken from a remote period of time; particularly when all Time-keepers, as the Doctor himself observes,

observes, do from time to time accelerate or retard their rate of going.

As there are but twelve months in the whole of Dr. Maskelyne's trial, and the first month is used to obtain a rate to apply to the succeeding parts of the trial, in consequence of which there are but eleven left, I have, in order to make the comparisons exact, rejected the last month, and applied the several rates to the first and last five months of the remaining ten; otherwise I should have confused the comparisons, by having six months in one period, and only five in the other; besides, that it might have been said that such a way of stating my case, would neither have been a fair, nor true one.

Upon applying then, Dr. Maskelyne's method to the two watches, it turns out, that the error of every separate month in succession is as follows:

		Green.	Blue:
First month being	}		
from 24th July		0' 11,2	0' 7,0
to 24th August			
September 24	-	0 11,8	0 4,5
October 24	-	0 23,7	0 14,3
November 24	-	0 43,2	0 53,8
December 24	-	1 17,3	1 10,4
January 29	-	1 03,9	0 58,2
			Blue.

		Green.	Blue.
February 28	-	1' 13,9	0' 58,1
March 30	-	1' 37,0	0' 58,1
April 30	-	1' 9,8	1' 38,6
May 30	-	0' 18,7	0' 49,0

Upon an examination of the above periods it will be found, that though they do not in *every* instance increafe in the amount of their error, as they become further distant from the first month, yet they do *generally*; and upon taking the sum of all the errors of the first five months, as to Green, it will be found to amount only to 2' 47",2; whereas, the amount of the sum of all the errors of the second five months is 5' 23",3, which is almost double the quantity of the first. And, as to Blue, the sum of the errors of the first five months, is only 2' 30",0; whereas the sum of the errors of the second five months amounts to 5' 22",0, which is more than double the quantity of the first period. Now then let us see how the errors of the same months will come out by comparing each month with the preceding one, or, in other words, taking a rate from the month preceding to apply to the succeeding one, instead of using the fixed rate taken from the first month, according to Dr. Maskelyne's method.

Between

Green.		Blue.	
Month.		Month.	
Between 1 & 2	- 0 11,1	Between 1 & 2	- 0 9,1
2 & 3	- 0 22,9	2 & 3	- 0 2,6
3 & 4	- 0 35,4	3 & 4	- 0 20,8
4 & 5	- 1 6,8	4 & 5	- 0 37,5
5 & 6	- 0 34,2	5 & 6	- 0 18,8
6 & 7	- 0 13,4	6 & 7	- 0 14,4
7 & 8	- 0 10,0	7 & 8	- 0 2,0
8 & 9	- 0 19,7	8 & 9	- 0 0,2
9 & 10	0 20,9	9 & 10	0 38,3
10 & 11	1 28,8	10 & 11	0 46,7

Hence it will appear, that the sum of all the errors of Green, in the first half of the time, viz. the first five months, is 2' 50",4, and in the remaining five months, or second half, 2' 32",8: And that the sum of all the errors of Blue, in the first period, is 1' 42",8, and in the second, is 1' 41",6: so that, in this way of coming at the errors, the quantity appears, as to both Time-keepers, to be a little greater in the first period than in the second; but the difference, instead of being outrageously great, as in the former instance with a rate taken from the first month, is too trifling to deserve notice.

When the Doctor comes to notice what I say about a rate being taken from the whole time of the going, to be applied to any of the intermediate spaces, he says this is very fa-

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vourable

vourable to myself, because, let the watch go
 ever so ill, it will just take off half the error.
 This assertion, however, I will take upon me
 to shew, is totally void of truth. It must
 be admitted, that the perfection of a Time-
 keeper consists in its always measuring an equal
 quantity of time in an equal space, and in
 order to know how you can come at its real
 error arising from its not doing so, I will put
 a case nearly like that I have used in my Nar-
 rative. Suppose that in a year, which to avoid
 fractions we will consider as consisting only of
 360 days, there be a gain of six minutes, which
 is exactly equal to a rate of one second a day,
 then if, upon the application of that daily rate
 of 1" to any number of days, weeks, or months,
 or (in the language of my Narrative) to any
 of the intermediate spaces of time, within the
 360 days, it shall turn out that there is no de-
 viation, there will in fact be no error in the
 Time-keeper. But if, instead of there being
 no deviation, it should turn out, that the
 Time-keeper at the end of one month has lost
 one minute, at the end of three months two
 minutes, and at the end of six months three
 minutes, upon applying the above rate of one
 second a day, the consequence will be, that as
 that rate will at the end of 30 days give a gain
 of 30 seconds, this added to the one minute
 lost

lost gives $1' 30''$ as the error upon the month; as also the rate at the end of 90 days, or three months, will give a gain of $1' 30''$, that added to the $2'$ lost will give an error of $3' 30''$: and as at the end of six months, or half a year, the daily rate will give a gain of $3'$, that added to the $3'$ lost will give an error of $6'$. Now, as the Doctor, after stating this method to be very favourable, says, that however ill the Time-keeper has gone, it will just take off half the error; let me ask him, how he can possibly make it appear, that as *half* the error will upon the application of such a rate be always taken off, the *whole* error at the end of the month ought to have been $3'$, instead of $1' 30''$; at the end of three months $7'$, instead of $3' 30''$; and at the end of six months $12'$, instead of $6'$. The only way by which I can form a guess, how the Doctor could fall into this egregious blunder, is by supposing that he has, in some way or other, confounded, in his own mind, the rate we are here speaking of, with the mean between the loss at the end of the first half-year, and the gain at the end of the second: and, indeed, if that mean be applied, as a rate to determine the error between the two periods, then I confess half the error arising from such a comparison would be got rid of; for in the case of $3'$ lost

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at the end of six months, and 6' gained at the end of the year, the error shewn by the comparison would be 9'; though, by taking the mean between $-3'$ and $+6'$ which amounted to $+1' 30''$, and applying it, either to the 3' lost at the end of the six months, or the 6' gained at the end of the year, the error, instead of 9', would only appear to be $4' 30''$, which would be just getting rid of half of it. But this mean is altogether different in its nature, from the mean daily rate I have spoken of, as taken from its gain or loss at the end of the whole trial.

As a further illustration of the arguments I have made use of in opposition to the rate adopted by the Doctor, I will put the case of a Time-keeper measuring unequal quantities of time in six successive periods of a month each, and that we are informed, not only of the sum of its deviation from mean time, or the standard by which it has been tried, at the end of the six months; but also of the sum of its deviations at the end of each month. Now, if it were required to ascertain the allowance to be made in the going of the Time-keeper for the succeeding month, so as to arrive at as great a degree of certainty, as the nature of the thing will admit of; as we find that all the several quantities of deviation in each month differ, and that too with a good deal of irregularity,

gularity, if it was doubtful to which we ought to give the preference, we should not take the largest, because it is found by the experience of the whole six months, that it is six to one that the quantity does not prove so large, nor would it be proper to take the smallest quantity, for the same reason; and, as the intermediate quantities do not agree, there would be the same reason for not giving a preference to any one of them: the only method, therefore, which remains, is to take the mean of the whole by dividing the sum of the six months by the number of the months, which will certainly give a much more probable rate or allowance to assist in ascertaining the going of the watch in the month succeeding, than either of the preceding months, taken separately, would have done; and *particularly the first*, because if there be any cause in existence to affect the rate of the watch, which did not exist when it was first set going, it is five to one it did not begin to operate in the first month: there is therefore abundantly more reason to expect an agreement between the rates of the months that are nearest to the one they are to be applied to, than between that, and the first of the six months, from which it is the furthest removed. If then it be allowed, that, in judging of the going for one month, it would be improper to
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take a rate from any month of the fix, which had preceded, in preference of the mean of the whole together, would not the probability of obtaining a fit rate be very much more remote, if the rate afforded by one month were to be applied to determine the going of the next fix; and yet the Doctor has not only done this, but even boasts of having applied it to periods of *fifteen* months; for in his statement of certain trials which lasted that length of time, a rate taken from the first month, he tells us, is the one he used.

I shall next consider what Dr. Maskelyne says about the first Time-keeper being deposited with Dr. Hornsby, in order that Dr. Hornsby's trial of it might be a check upon his own, which he notices in p. 35, and 61, of his Answer, where he charges me with a mis-statement in the following passage quoted from my Narrative; "that my Father, after having completed his Time-keeper, put it into the hands of Dr. Hornsby, thinking it expedient, that some other public character, besides Dr. Maskelyne, should be acquainted with its going; and that after Dr. Hornsby had tried it for four months, during which time it went with great accuracy, it was committed to the care of Dr. Maskelyne; but that it was soon found, that if the Time-keeper continued to
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go under his care in such a manner as to deserve the public attention, it would not be occasioned by his good treatment of it, but because it was not an easy matter to do it any injury," stating that it was tried by himself, for two months, before it was put into the hands of Dr. Hornsby. I am very ready to acknowledge that it was tried by him for the two months he mentions, and the event of that trial made it evident, that it was necessary to have some check upon him in future; for it was during that period that the Doctor carried the Time-keeper to and fro, and up and down stairs, contrary to the wishes of my Father and his friends, as I have before related, till he was absolutely prohibited from so doing by an order of the Board of Longitude; and it was during the same period, that the fatal stopping of it happened, of which the Doctor has given so very lame an account. Therefore, though the Doctor entertains so very high an opinion of the privileges annexed to the office of Astronomer Royal, as to suppose it exempts him from all censure or control, it was highly necessary for this very reason, that the Time-keeper should be tried by some character of distinguished eminence, to operate as a check upon him, and thereby, if possible, prevent any future enterprizes of the same kind. And
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the Doctor's eagerness to convict me of petty mistakes with respect to times and dates, with which I really do not profess to have been accurately acquainted, and which I have not in fact stated in the passage alluded to, has only tended to occasion an enquiry, which has turned out much to his disadvantage *.

The Doctor observes, p. 63, that " when the Time-keeper was returned to the Royal Observatory, after [having been tried by Dr. Hornsby, it went at first at the same rate as it did with him before the removal, and afterwards went *full as regularly* with him as it had done with Dr. Hornsby ; its rate indeed being gradually accelerated with him as it had with Dr. Hornsby, but his trial lasting fifteen months, the acceleration of rate became considerable with him, amounting to 8", and therefore the watch might seem to a superficial observer to have gone worse with him than with Dr. Hornsby, it only having accelerated its rate by about $1\frac{1}{2}$ ", in the course of Dr. Hornsby's four months trial. As the Doctor has not thought fit to publish an ac-

* My Father had so little apprehension of his Time-keeper not been found to possess, upon fair trials of it, a superior degree of excellence, that, besides the trial by Dr. Hornsby, it was also tried by Count Bruhl, Dr. Heberden, and Dr. Demainbury.

count of the going of the Time-keeper from day to day, I am not furnished with proper materials to make a comparison of the first four months of its trial with him, and the first four of its trial with Dr. Hornsby, with the degree of exactness I could wish; therefore if I should happen to be incorrect in what I am about to say, I shall be very willing to retract any thing which upon further information may prove to be erroneous. Now it appears to me, as far as it can be judged from the table of its monthly going, which the Doctor has given in No. 4 of his Appendix, that the Time-keeper must have accelerated more than $1\frac{1}{2}''$ during the first four months of his trial of it, contrary to what he has asserted; and therefore, according to the reasoning he has adopted, must have gone worse with him, than with Dr. Hornsby. For the table shews, that during the first month, which consisted of thirty days, it gained $3'',57$, consequently its mean daily rate must have been $+0'',12$; and that during the fourth month, which consisted of twenty-eight days, it gained $59'',99$, of course its mean daily rate must have been $+2'',14$, and therefore the acceleration of its rate during the four months must have been more than two seconds: and, if we proceed to the fifth month of its trial by the Doctor, it will ap-

pear from the table, that there must have been, comparatively speaking, a most extraordinary acceleration during that month, which is not very easily to be accounted for upon the principle of a *gradual* acceleration, which the Doctor assures us took place during his trial of it.

The Doctor afterwards proceeds to notice the trials of the Time-keepers, Green and Blue, which my Father made in consequence of receiving the 500l. ; and here he certainly supplies a deficiency in my history of them, by stating a second trial of them in the years 1783 and 1784, which I had omitted to mention, though not intentionally, as the Doctor supposes ; for if I had been inclined to omit any trial intentionally, it certainly would have been the first, when they went the worst, and not the second, when their going was so much superior. But though they went very much better in the second trial than in the first, I freely admit they did not, in that trial, go within the limits of the Act. I shall, however, avail myself of what the Doctor has said of that trial to observe, that their variation from themselves in gaining or losing, amounted only to 9",5 in *fifteen* months : whereas Mr. Harrison's Time-keeper varied 28" in *eight* months, which is little more than half the

the time; and with respect to the errors, as they appear by what they had gained or lost at the end of the first and second six months, it always turns out, as I have before observed, that the application of the Doctor's rate makes them appear greater than any of the other rates, which have been deemed proper ones for this purpose.

The Doctor having now come to the conclusion of the last trial of the two Time-keepers, speaks of my charging him with having stated, after the trial was over, that both of them had gone within the limits; namely, that one had gone within the strictest limits, and the other within the most extended ones. This the Doctor denies he ever said, and affirms, that the extent of what he mentioned to the Board, and also to Mr. Dutton, was, that he believed one or both of the watches might be found to have gone within some of the limits required by the Act, but could not be sure, not having completed the calculations. Mr. Dutton, upon being applied to, denies that the Doctor ever used these expressions to him, or that he has at any time since, acknowledged to the Doctor that this was the case. However, I did not allude to Mr. Dutton, as being one of the persons to whom he made the declaration I have charged him with.

But Mr. Matthew Dutton, Mr. Dutton's eldest son, was ; and he has so perfect a recollection of the Doctor having told him in direct terms, that the Watches had gone through their trial within the limits of the Act, without saying a syllable of his not being sure, or not having made his calculations, that he would very readily swear to the truth of it ; and he says he remembers having, in consequence of this information, a good deal of conversation with the Doctor as to the further trials they were to undergo, and particularly asked him, when they would be sent to sea ? when the Doctor told him, that at the next Board, the Admiralty would be applied to for a ship for the purpose, but on account of the armament that was then fitting out by Government, and the prospect of a war, he thought it very uncertain as to the time when a ship would be granted them. This account is certainly a very circumstantial one, and upon enquiry will, I am sure, be found to agree better with what Mr. Matthew Dutton has *actually* told me, than I learn from Count Bruhl Mr. Emery's story, told by the Doctor, is likely to agree with the information he actually received from Mr. Emery ; as, from what the latter has since said of the fine wrought-up story

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the Doctor has told for him, he seems by no means disposed to swear to the truth of it.

In addition to the evidence which Mr. Matthew Dutton can give as above, it may also be further noticed, that when the Doctor sent the register of the going of the Time-keepers to Mr. Dutton the elder, he also sent his compliments, and was sorry he had been *mistaken* in asserting the Time-keepers had gone within the limits of the Act; and as by this time Mr. Dutton thought it would not be amiss to have as certain evidence of the truth of what passed as he could, he immediately made a note in a blank leaf of the register, that such was the message the Doctor sent.

The Doctor next proceeds to say, p. 80, that he was induced to mention what he then believed, without having made the calculations to ascertain the matter, out of *good will* to my father, that he might take the advantage of cleaning his watches, previous to such further trial as they might become entitled to, if his opinion of their good performance should be verified upon calculation; and afterwards observes, p. 81, that his solicitude for the Watches being returned to my Father to be cleaned, previous to such further trial, as they might be appointed to undergo, shews almost as plain as any thing can do, that he
was

was not then unfriendly to the Watches, for that had he not wished well to them, he should have scrutinized more nicely into their going before he spoke about them, and not have taken so much pains to recommend the cleaning them preparatory to further trials. To this I answer, that as the cause of the Doctor's solicitude to have the Watches returned to my Father must forever remain locked up in his own breast, it is impossible fully to ascertain *all* the reasons which gave birth to it; but I think we may form a very probable guess as to *some* of them, and may arrive at still more certainty with respect to what were *not* the reasons which made the Doctor so solicitous upon this head. That the Doctor's solicitude to get rid of the Time-keepers did not originate in that good will to my Father, and friendly anxiety for the success of his invention, to which he pretends, is evident from this circumstance, that though the Doctor was told, more than once, that my Father was desirous that the Time-keepers should go through all their trials without cleaning, that the public might have the clearest evidence of their permanence, and utility, and that he was perfectly satisfied that there would be no occasion for their being cleaned; yet the Doctor again and again pressed to have them taken away for that purpose,

pose, and, not succeeding in his *own* applications, the letter, I have mentioned in my Narrative, was written as late as on the 10th of November following, for the same purpose, by Sir Harry Parker, Secretary of the Board of Longitude, upon a resolution of the Board made more than five months before. Whether the Doctor was in hopes, that, if the watches were taken to pieces to be cleaned, they would alter their rate of going, as he states Mr. Harrison's to have done, which might have afforded him the means of condemning them in their future trial; or whether he thought they would, after being put together again, require an unreasonable time for their adjustment, which he might have urged against their being an invention generally practicable and useful, and which he has, though without any reason, occasionally insinuated in different parts of his Answer; or what other reasons he might have had, must be matter of conjecture to every one but himself: but it certainly was no proof of his friendship for a man, to desire that to be done, which he knew he was averse to, and was *assured* was contrary to his interest; and to pretend that it was, throws such a dark shade of suspicion over the whole transaction, as the Doctor will find it very difficult to remove.

After

After this the Doctor mentions the memorial I presented to the Board of Longitude, praying they would, under the discretionary power vested in them, bestow upon my Father such a reward for his Time-keepers, as they should think he deserved. He tells us, "the Board did not chuse to exercise this power in the present instance," and then adds; "nothing to explain the motives that might guide their opinions in not granting this favour to Mr. Mudge is put on the minutes." Now I believe the only motive was his inveterate opposition to the justice, and propriety, of the measure; for Dr. Hornsby told me, when the Board broke up, that nothing had been done for my Father; but that he believed there was not a member present, who would not have given the reward that was asked, if it had not been for Dr. Maskelyne; and though the Doctor has accused me, in another part of his pamphlet, of having suppressed the information he supposes Dr. Hornsby must have given me about Mr. Eyerard's Time-keeper, of which I shall speak hereafter, I assure him, I do not recollect that Dr. Hornsby told me any thing more than I have mentioned in my Narrative, except what I have just related.

The Doctor then proceeds to state some of the arguments that were used at the board,
why

why a reward should not be given to my Father (and which I apprehend were arguments used by himself), and among others, says it was mentioned, that watches had been made by other watchmakers, superior to those of my Father. Mr. Arnold, Mr. Earnshaw, and Mr. Emery, were the three that were particularly mentioned, and I have not the least inclination to detract from their real merits, but I insist, that they never have made Time-keepers of equal excellence with those of my Father, however inclined Dr. Maske-lyne may be, in order to serve his own purposes, to exalt *their* characters, with a view to depreciate *his*. And I am very sure, that there are no Time-keepers in existence, made by any of these artists, or by any other person, which have been in use for several years, and still preserve so great a degree of perfection, as to go generally within half a second a day; a degree of excellence, which not only the two Time-keepers that were last rejected, and are now with Mr. Dutton, continue to possess; but also the first, which was made about eighteen years since, and is now going in the hands of his Excellency Count Bruhl. As I am at present speaking of the actual merit of my Father, in comparison with that of other watchmakers, I will mention one proof of his superiority, which, to my mind, is incontro-

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vertible,

vertible, which is, that the native vigour of his genius, enabled him to strike out *at once*, those principles of construction for his Time-keepers, which were calculated to impart the greatest excellence to them; and it is a fact, that though Mr. Arnold, and other Time-keeper-makers have been continually altering the construction upon which they have made their Time-keepers, because they found, from time to time, that they were not to be depended upon, my Father has never made any alteration in the construction or invention of his, but they are exactly the same now, as they were in the year 1774, when he finished the first he made*; and, in consequence of this certainty in their principles, they have not gone, some well, and some ill; but all the three successively, which he has made, have invariably arrived at a great degree of excellence. If, therefore, such Time-keepers, as may be made upon the plan of my Fathers, should at any time go amiss; as it will not be from any failure in the principles of their construction, but merely, either from their not being so well adjusted, and regulated, as they would

* The improvements which have been mentioned to have been made in my Father's Time keepers from time to time, have been merely alterations in the mode of adjustment; but the principles still remain the same as they were at the first.

admit of, or from some accidental defect in the workmanship, or materials, or want of oil, or cleaning; the same Time-keeper might always be made to answer its intended purpose by the removal of these accidental causes of error, when at any time they may happen to occur; and which, having nothing to do with the principles, will readily discover themselves upon examination. Now it is very well known, that this is by no means the case, as to any inventions which other watchmakers lay claim to, and I know very well, that Mr. Arnold has been continually, from time to time, challenging the approbation and applause of the public, for a variety of alterations in the construction of his Time-keepers, by each of which, at the time, he was of opinion, he had got rid of every material error; but for want of that certainty of principle, to which my Father's Time-keepers owe their excellence, he has never been able to depend upon making two or more Time-keepers in succession, upon the same principles, possessing nearly equal degrees of perfection; for it has happened, that when he has made one that has gone well, the next he has made has turned out very indifferently. Of this fluctuation in the principles, and variation in the construction, of his Time-keepers, I am furnished with proof, which can be produced

if necessary. And I believe, were it to be enquired into, it would be very likely to turn out, that his Watch, which was tried by the Board of Longitude, in 1779, and 1780, and Mr. Everard's Watch, both which are stated to have gone so well, are not made upon the same construction; in which case, whatever might be the merit of the Watches, separately considered, their respective principles are not to be so much relied upon. Should Mr. Arnold think I have said too much about my Father's merit, as opposed to his, he must recollect, that he provoked the comparison by his own publication, which came out before my Narrative, where, though he does not deny that my Father possesses considerable merit, he nevertheless insists upon it, that *he* has done the most service to the public, and is in fact the greatest watchmaker that ever lived. But though it appears from what I have already said, that I am not of the same opinion, yet yet I am very ready to acknowledge, that I think the public much indebted to him for his active and enterprising disposition, by which many much better Watches and Time-keepers have been made than otherwise would.

Dr. Maskelyne observes, that I have gone out of my way to ally my Father's cause with Mr. Harrison's;

Harrison's ; but I cannot help thinking there is so close a resemblance between them, that they seem naturally to ally themselves. I have always been led to consider my Father's case, and Mr. Harrison's, to be similar ones, from an opinion that they were both men of genius, whose abilities have been engaged in the pursuit of the same object, in which pursuit both have met with the same opposition from a prejudiced individual ; with this only difference, that in the end Mr. Harrison, when he was near eighty years of age, got 20,000 l. as a reward for his labours ; though my Father, whose genius, and merits, may by his *friends* be thought equal to Mr. Harrison's (for he does not pretend to superiority) who has made 'Time-keepers, which have been found to possess a degree of perfection many times greater than those of Mr. Harrison, and who, like Mr. Harrison, has spent the greater part of a long life in the pursuit of objects of public utility, after having attained the same age, has, for *his* labours, received as yet but 500 l. and is now by increasing age, and infirmities, at last deprived of the power, however strong his inclinations may be, to attend to them any longer.

With respect to what the Doctor observes, relative to my having mentioned his being peculiarly

cularly interested in the construction of the lunar tables, where he says, that he pays over all that he receives for this purpose to the various computers and comparers of the calculations, and produces his vouchers, and passes his accounts, for every farthing of it. I can only say, that I was positively told so, by a person I had every reason to suppose well informed upon the subject; and, besides this, found the same thing asserted by Mr. Harrison in his pamphlet written between twenty and thirty years ago, which has never been publicly contradicted. I trust therefore the world will readily acquit me of any thing like intentional falsehood, and when they are informed, that, since the year 1774, 25000 l. have been granted to the Board of Longitude by Parliament, a great part of which has been distributed by the Doctor to such persons as he has employed, or recommended, they will be inclined to think him interested, though not in a pecuniary way, in consequence of the extensive patronage he by this means enjoys.

In reply to what Dr. Maskelyne says, p. 67, of the intention with which I introduced the accounts in my Narrative of the going of the first Time-keeper with Dr. Zach, and Admiral Campbell; I acknowledge that I did so, with a view to induce a belief that it had gone in the hands

hands of other persons better than with him *, which I trust I have manifestly shewn already in more instances than one; and I am very much deceived, if I do not at present most clearly prove, according to the Doctor's own shewing, not only that the first Time-keeper actually did go better with Admiral Campbell, and Dr. Hornsby, but that the second, and third, also, went with greater accuracy with Mr. Dutton. With respect to the trial of it by Dr. Zach, though I have no where said so, I am likewise informed his experience of it will prove the same thing to have happened with *him*; but on this last head I shall not take it upon me to state any thing positive, being

* In addition to what I have already mentioned, and shall hereafter notice on this subject, I will give the following extract from a letter written by my Father to Mr. Dutton, on the 28th of December 1779, and leave it to the Reader to form his own opinion of it. " You give me but a bad
 " account of the Watches at Greenwich, I am resolved not
 " to suspect the integrity of those under whose care they are,
 " till I have some glaring proof of unfair dealing; though
 " I assure you, that which I have here," (meaning the first Time-keeper) " though nothing has been done to it except
 " putting some oil to it, when you sent it down two years
 " ago, goes incomparably better. I have been obliged to
 " make use of it as my regulator for eight weeks past, and
 " I found by a transit of the sun two days ago, that the
 " observed error differed only about ten seconds from the
 " error computed from its rate of going."

obliged

obliged to say, as the Doctor has before me, that I cannot read German, and therefore have not been able to inform myself, with as much certainty as I could wish, of all Dr. Zach has published upon the occasion. As it may however appear a little extraordinary, that I should have given in my Narrative part of the contents of a German publication (I mean the Berlin Ephemeris) I beg leave to say that a gentleman in the law, who is an intimate friend of mine, had the goodness to translate, and explain, part of it to me. But as I apprehend it is Dr. Zach's intention to say a great deal upon the subject of the merit of my Father's Time-keeper, as it appeared while it was in his possession, which was for no short period; as well as to justify himself against the supposed heavy charges, which Dr. Maskelyne has exhibited against him, I shall leave all that relates to the Time-keeper, during the time he had the use of it, to be the subject of such future observations, as he may think it expedient to make; being fully persuaded, that whatever may be the opinion he has formed of it, from the long trial he has had, will be given to the public with the utmost justice and impartiality.

I shall now proceed to what the Doctor has said, relative to the instances mentioned in my Narrative of the excellence of the
going

the going of the first Time-keeper while in the hands of Admiral Campbell, and of the very honorable testimony, which the Admiral frequently bore to its merit.

The Doctor, not being able to deny the acknowledged abilities, and scientific acquirements, of Admiral Campbell, was sensible his opinion would have great weight, and finding himself hard pressed upon the occasion, was obliged to call in to his assistance his favourite lunar method; which, with a little management, he hoped would enable him to deprive the Time-keeper of the greatest part of the credit it had acquired with the Admiral, from the repeated experience he had had of its accuracy. Having therefore observed, that the Admiral had a considerable share in recommending the lunar method to public notice, and consequently could not be supposed to have neglected it in his own practice; he introduces a comparison, in his usual way, between this method of determining the longitude, and that by Time-keepers, in which, by a most palpable misrepresentation, he endeavours to make it appear, that the lunar method has manifestly the advantage; and then insinuates, that the Admiral principally relied upon it. The Doctor's words are (p. 70) that "the lunar method is an *absolute* method of finding

the Longitude, *whenever* lost: whereas that by a Time-keeper is only a mode of keeping the Longitude on from one known place to another, or from that determined by a lunar observation to the next observation, or to seeing land." Now, unless we suppose the Doctor to have been more ignorant of his own boasted method, than he will be willing perhaps to allow, it is evident that he has made use of language, which he well knew not to be true. The lunar method is *not* an absolute method of determining the Longitude, *whenever* lost; for, as the Doctor very well knows, the moon is for six days in every month too near the sun for observation; therefore the Longitude cannot be determined by it on any of those days: the Sun and Moon, are also for twelve other days in every month, either at too great a distance to be observed at the same time, or are not at the same time visible; consequently, during that period, nothing can be done at sea by the lunar method, without calling in the assistance of a Timekeeper. Moreover it frequently happens to Navigators, that the weather, during great part of a voyage, is such, that though the place of the Sun, by reason of his superior brightness, and splendour, can be readily determined by day; yet neither Moon, nor Stars, are to be perceived at night. At
such

such times the Time-keeper is of the utmost importance for determining the Longitude, while the lunar method is totally useless. I might here add, if it were necessary, that the lunar method, however perfect it may be supposed to be in theory, cannot be absolutely depended upon to any very great degree of exactness in practice; which is a circumstance the Doctor has thought fit to conceal. He is, I have no doubt, perfectly well apprised, that very excellent astronomers, and observers, have ridiculed the idea of any observation of the Moon, at sea, however carefully made, being to be depended upon for ascertaining the Longitude within *two* degrees; but should we grant, that by an extraordinary degree of nicety in the observation, and the use of instruments of superior excellence, it should be determined within *one* degree, what is this, compared to what was accomplished by the Time-keeper during the voyages to Newfoundland, which according to the most unfavourable calculations the Doctor could make, even admitting them to be true, determined it within *one sixth* of a degree. With respect to the latter part of the Doctor's comparison, that the Time-keeper is only a mode of keeping the Longitude on, from one known place to another, or from that determined by a lunar observation

to the next observation, or to seeing land; I will only ask him what he can wish for more. If he was about to embark for Madras, would he wish for any thing more, than to keep on the Longitude from London to Madras; or from any other place, of which the Longitude had been ascertained by the lunar method, or any method, till he saw land. If he does, I am sure it is what no professional man would; for him it would be quite sufficient to keep on the Longitude, as the Doctor terms it, from the place he sailed from, to the place of his destination; or from such place, as he had by any means determined the Longitude of, till he again saw land. As the Doctor's language, however, is not very clear, he may perhaps mean, that the Time-keeper is not capable of ascertaining the Longitude in any of the intermediate stages between the place of departure, and the place of destination, and his words may possibly be made to bear that construction; but if he means this, he is mistaken, for the Time-keeper is as capable of ascertaining the Longitude at any intermediate period of the voyage, as it is at the end of it. Probably he may suppose, that the Time-keeper might be occasionally let down, as has sometimes been the case at the Royal Observatory; but no one, I conceive, would think himself entitled to impeach the
excellence

excellence of the method, for his own negligence and carelessness in the use of it.

The Doctor takes it for granted, p. 71, on the strength of a cavil upon the meaning to be annexed to the word *contribute*, and a question which he asks, and no doubt supposes the reader will answer according to his wishes, that Admiral Campbell, on his voyage from Newfoundland, when he put so much confidence in the Time-keeper, and made the land at the time indicated by it, had as great, or still greater confidence in the lunar method; which the Doctor supposes in his question, but without a shadow of authority, corrected the errors of his reckoning, and shewed him what dependence he could place upon the Time-keeper. Now, the Doctor ought to know, that words are to be interpreted according to the subject matter, and that, in common conversation, the phrase that such a thing contributed to effect such a purpose, means frequently that it absolutely effected it; and that this was Admiral Campbell's meaning, must be obvious; for he never mentioned that the lunar method contributed partly to induce this confidence, which he would of course have done, if, as the Doctor imagines, it had as great, or greater, a share in it, than the Time-keeper. Besides, if the lunar method pointed out the errors of the

Admiral's

Admiral's reckoning with so much precision, as, according to the Doctor's supposition, to render the Time-keeper almost useless, how comes it, that it did not equally point out the errors of their reckoning to the Commanders of the other ships which accompanied him; who beheld him, with a considerable degree of apprehension, leading them, as they supposed, to certain destruction. It is therefore manifest upon the face of the thing, that the Admiral's dependence was upon the Time-keeper, and the Time-keeper only. And so it turns out upon enquiry, for when he made the land, he had had no observation of the Moon for some days, consequently the lunar method is totally out of the question.

With respect to the rate applied by the Doctor to the going of the Time-keeper in the voyage out, the first time it was carried to Newfoundland by Admiral Campbell; I shall only observe, that I have not the least inclination to differ with him about it, though by its use the Longitude would appear to have been determined only to ten miles and a quarter; as this, I am informed, is deemed by professional men to be a degree of exactness perfectly sufficient for all nautical purposes, and very well to warrant the declaration the Admiral made; which, though the Doctor affects to
 Columbus doubt

doubt it, can be proved by the testimony of respectable witnesses, who have heard him repeat it more than once.

The Doctor, in answer to that part of my Narrative, in which I say that this Time-keeper, during the second voyage to Newfoundland, went with seven times the degree of perfection the Time-keeper made by Mr. Kendall, as a copy of Mr. Harrison's did, which Admiral Campbell, during the same voyage, had also under his care; remarks, that this was not the Time-keeper Mr. Kendall made as a copy of Mr. Harrison's; but the third he made for the Board of Longitude, in which he had departed greatly from the construction of Mr. Harrison's. In reply to which, I will very freely acknowledge, that having heard generally, that it was made after Mr. Harrison's Time-keeper, and not knowing that Mr. Kendall in making it had in some respects departed from his model, I was probably incorrect in stating it to have been a copy of Mr. Harrison's. But if the reader should be desirous of knowing, what has been the comparative rate of going between my Father's Time-keepers, and that made by Mr. Harrison himself, he will find, in p. 34 of my Narrative, that one of them has gone with seven times, and the other with nine times the perfection Mr. Harrison's did, a circumstance

stance which the Doctor has not thought proper to deny.

We are next told, p. 75, that "the run between England and Newfoundland, which only takes up a month, is much too short to afford any argument for the sufficiency of the Time-keeper to determine the Longitude in a six months voyage, within the limits required by the act;" but the Doctor, whose memory seems to adapt itself to his convenience with a wonderful degree of flexibility, has taken care to forget, that Admiral Campbell's observations of its going comprize, in the first voyage, a period of near *five months*, that is, from the 31st of May, when he received it from Count Bruhl, to the 24th of October, when he made his last observation upon it at Newfoundland; and in the second voyage, a period of more than *five months and a half*, that is, from the 9th of May, when he again received it from Count Bruhl, to the 28th of October, when he made his last observation at Newfoundland. And though a single month might be too short to afford any argument of its sufficiency to determine the Longitude for a six months voyage within the limits of the act; yet when the reader is informed, that it went during these two periods, one of near five months,

months, and the other of more than five months and an half, and in neither of them erred to the extent of *two* minutes, he will think it, I fancy, a very strong argument, that it would not, in six months, have erred to the extent of *four* minutes, which are the limits the Act prescribes.

The Doctor then informs us, that the result of the trials (meaning with Admiral Campbell) do not shew, that the Watch went better than it did with him during an equal space of time; which he endeavours to make appear by comparing its going at Greenwich in four periods of a month each, between November 11th, 1776, and March 11th, 1777, when he says it varied 9" more in the second period than in the first, 24" more in the third period than in the second, and 24" more in the fourth period than in the third. Now here it may be worth while to notice, how eagerly the Doctor has recourse to comparisons of periods of equal length, when it promises to afford him any advantage. After observing in my Narrative, that this was the method he had adopted to condemn Mr. Harrison, I predicted that he would set it up again upon some future occasion, and the present instance tends strongly to shew that my conjectures were not ill founded.

When it was my father's object to establish the

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merit

merit of his Time-keepers; the Doctor contended that their goodness should be determined by applying a short period of time to a long one. Now, it is his own wish to prove the excellence of one of them for a given space of time, upon finding it likely to be of service to himself, he has recourse to a comparison between periods of equal length; but still keeps as far as possible from a comparison of the whole time, during which its going is to be determined, with another period of the same length; instead of which he splits it down into small portions, and compares those portions with each other; when, as if afraid, he had said too much in favour of the Time-keeper, he takes care to insinuate, though it had nothing to do with the object before him, that "this does not prove that it will always go so near, for that in the fifth period it varied 52" more than in the fourth:" where he drops the comparison, leaving it to the Reader to presume, that as it varied 52" more in the fifth period than in the fourth, the variance was still greater in those succeeding; whereas, upon making a calculation from the data afforded by his own table, it appears, that in the 6th period it varied only 5" more than in the 5th, in the 7th only 2" more than in the 6th, and in the 8th only 6" more than in the 7th.

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This conduct I shall leave to the reflections of the Reader, and proceed to observe, that whatever may be the use of a comparison between small successive portions of equal length in the course of a given trial, as applied to that same trial; yet, where the relative goodness of a Time-keeper in two different trials is to be estimated, it is necessary to compare the whole of the one with the whole of the other; for notwithstanding certain given periods in the one trial, may not have varied more from each other than the corresponding periods in the other, yet this may not be the case with other given periods in the same trial, and it may turn out, that the whole of one trial, may have varied considerably more than the whole of the other, from any certain standard applied to the entire extent of it; the truth of both which positions will be presently evinced, from these very trials, in the comparisons I am about to make. The question, therefore, is, whether the Time-keeper during the whole of the four months it was with Admiral Campbell, went better than it did with Dr. Maskelyne during a period of equal length. I acknowledge, that for want of a trial of four months, previous to the delivery of the Time-keeper into the Admiral's hands, the whole time could not be compared with a period of equal length, but

it would have been coming as near to it, as the nature of the case would admit, to have compared the first two months with the second two; and, if the Doctor had done this, it would have appeared, that the variation from mean time was $+ 12''$ at the end of the first two months during which it was with Admiral Campbell, and $- 4''$ at the end of the second two months, the difference consequently is but $16''$; whereas the variation at the end of the first two months it was with the Doctor was $+ 16''$, and at the end of the second two months was $+ 112''$, the difference consequently amounts to $96''$; which being compared with the two periods during which it was with Admiral Campbell, its error appears to have been not less than $80''$ greater with the Doctor, than with the Admiral.

I shall also state some other points of comparison, which the Doctor has *prudently* passed over in silence. At the end of the four months, during which it was with Admiral Campbell, the Time-keeper was found to differ from mean time only $1' 21'' 15$; but at the end of the four months it was with the Doctor it was found to have differed $1' 51'' 96$, consequently the error was $30''$ greater with the Doctor than with the Admiral. Also at the end of six months wanting but nine days, after having performed

performed the voyage to Newfoundland, upon being returned to Count Bruhl, on the Admiral's return to England, it was found to have varied from mean time only $+ 1' 29'' .25$; whereas at the end of the six months, during which it was with the Doctor, it appears by his table to have varied $+ 5' 31'' .75$, or more than four times as much. The Doctor may perhaps object, as he has done p. 72, that I have not allowed for any daily rate in making this comparison, and that we are not to allow a rate, or let it alone, as best suits our preconceived ideas; but I shall just venture to suggest to him, that no rate he can devise will make the error upon this occasion appear to have been any thing like as great with Admiral Campbell, as it was with himself.

I shall now take notice of what the Doctor has asserted, p. 111, namely, that upon a comparison of the daily rates of the Time-keeper during four months and a half's trial of it by himself, between November 11, 1776, and March 24, 1777, deduced from periods of a week, to resemble, as nearly as possible, the intervals between the observations, from which the rates had been deduced by Admiral Campbell, it appeared to have gone full as well in his as in the Admiral's trials; that is to say,
that

that its daily rates had not varied more in his, than in the Admiral's. Not to take notice of the obvious unfairness of comparing two distinct periods of four months and an half each, during which it was tried by Admiral Campbell, with a single period of four months and an half during which it was tried by himself, I shall easily make it appear, that the comparison turns out much to the Doctor's disadvantage; for though the variation, as thus taken, was 24" in the Doctor's favour upon the second period, it was 1' 61" against him upon the first, consequently the balance is 1' 37" against him,

I shall close this part of the subject with one remark more, which, I trust, will make it perfectly unnecessary for me to recur to it again; namely, that though the Time-keeper during the Doctor's trial of it does not appear to have gone within the limits, that is, within four minutes in six months; yet, during the first trial of it by Admiral Campbell, it appears, at the end of near five months, to have gone within 1' 41" though no rate be applied in its favour, which when properly taken is, as the Doctor contends, undoubtedly an advantage; and with the rate deduced by the Admiral, which the Doctor has himself made use of for the purpose, within 43"; and that, during its second trial with the Admiral, it appears, at the end of near
six

fix months, to have gone within 7" without the application of a rate, and within 30" with one.

The Doctor, p. 75, speaks of my having, as he apprehends, intentionally omitted to notice the two Watches having been tried twice, instead of once, before their final trial. I beg leave to say that I did not know they had been tried twice; and indeed if I had known it, and had thought it my interest to mention only one of the trials, I should, as I have before observed, instead of dropping any mention of the intermediate one of 1783 and 1784, which the Doctor charges me with having done, have been induced to have begun with that trial, and to have omitted the trial which took place in 1779 and 1780; both because the trial of 1783 and 1784 was, according to the Doctor's Register, more favourable to the Time-keepers than the former one, and because it was nearer to the final trial of them in 1789 and 1790. Indeed the difference between the first trial, and that in 1783 and 1784, which the Doctor pretends I have intentionally omitted, is so remarkable, that the most careless observer must be struck with it; for in the first trial the variance of rates amounted to 11" as to Green, and 18" as to Blue; and the quantity of error as to Green to 27' 52", and as to Blue to 50' 23": whereas in the trial of 1779 and 1780 the variance

riance of rates, as to both Time-keepers, which happened to be alike, amounted only to $9''$, $53''$ and the quantity of error as to Green, only to $9' 43''$, and as to Blue only to $19' 6''$.*

In answer to that part of my Narrative, in which I observed, "that Mr. Harrison, with the most perfect knowledge of the character of his judge, had wisely requested, that a person should be appointed by the Board to attend at the daily observation of the Time-keepers, as a check upon the Doctor, and that they should be screwed down in the box in which they were contained, to prevent any mischief from being done by removing them from place to place, or putting them down with such violence, as machings of this kind are not fitted

* This furnishes us with another strong proof of the insufficiency of the Doctor's monthly rate; for although, in determining the excellence of the Watches upon this trial by the variance in the daily rates, they happen to be one as good [as the other, yet the difference in their respective errors, by the application of the rate taken from the first month, is in the proportion of $9' 43''$ to $19' 6''$. And this appears still more glaring in what the Doctor says in his note, p. 76, as to the two Watches in their last trial; for he there informs us, that in the course of the year's trial Green had varied its rate $9''$, and Blue $5''$; yet he tells us, that by the application of his rate Green had only gained $5' 13''$, although Blue, which had varied so much less in its rate, had by the like application gained $8' 7''$.

to bear ;” the Doctor says, that Mr. Harrison was not consulted about this trial, and would have been indignant at the proposal ; and then states that this method was pursued by direction of the Board of Longitude on the suggestion of the Earl of Morton to ascertain the truth more fully against cavils, and for his security. But I am by no means convinced by what he says, that this regulation did not take place in consequence of the opinion Mr. Harrison had expressed of the Doctor’s conduct ; and to shew what opinion he entertained of it, and of the manner in which this regulation was executed, I will insert the following extract from his book. Mr. Harrison first gives the following passage from Dr. Maskelyne’s printed account of his Time-keeper, and of the Doctor’s management of it while it was in his possession. “ I most days wound up, and compared, the Watch with the transit clock of the Royal Observatory myself. At other times it was performed by my assistant, J. Dymond, and afterwards William Bailey : this was done in the presence of, and attested by, one of the Officers of Greenwich Hospital, when he came to assist in unlocking the box in which the Watch is kept, in order to its being wound up.” Upon this passage Mr. Harrison observes as follows :—“ Not one of

these attestations appears in the book. Perhaps Mr. Maskelyne thinks his assertion of the fact will be sufficient for the public; and indeed so it might have been to me, had I not received different information: but the truth is, the Commissioners appointed a set of Gentlemen to attend, by rotation, the winding up of the Watch; they were to unlock the box the Watch was in, to see it wound up and compared with the clock, then to lock the box again, and take the key with them; and Mr. Maskelyne was to have another key, there being two locks to the box. The Officers of Greenwich Hospital were appointed for this service, some of whom, from the infirmities of age, and misfortunes in the service, were scarce able to get up the Hill to the Observatory; so that when they came there, as can be proved from undoubted eye-witnesses, they only unlocked the box, sat down till Mr. Maskelyne had done what he thought proper, and then locked the box again, and departed: and whatever attestation they may be supposed to have made, I can prove, that at several times, when Gentlemen of my acquaintance happened to be present, the attendance of the Officers was by no means an effectual check upon the comparison of the watch with the clock. I would
not.

not be thought to accuse those Gentlemen of neglect of the duty imposed upon them; on the contrary, I applaud their diligence, in being ready at all hours of the day to attend, when Mr. Maskelyne was pleased to appoint; and therefore I will even for the present (though contrary to fact) suppose they have been the check proposed by the Commissioners of Longitude, against any unfair access to the *Watch*, still the clock with which it was compared was left entirely in Mr. Maskelyne's power, and an alteration of the one could not but produce just the same effect as an error of the other; nor is there even the least pretence of a check, either on the clock, or on its comparison with observations of the sun; nay, on the contrary, Mr. Maskelyne did at this time take the key of the clock from Mr. Dymond, in whose custody it used to be, and kept it himself*."

As to the questions the Doctor asks, p. 79, whether any one would believe, that if Mr. Mudge had been persuaded he was a deter-

* From what I have been told, I apprehend, the person who wrote Mr. Harrison's Pamphlet for him was the celebrated Mr. Short, who, to testify the indignation he felt at the ill treatment Mr. Harrison had in particular received from Dr. Maskelyne, generously afforded him the assistance which he conceived to be due to a man of worth and genius,

mined enemy to his Time-keepers, he, having a great object at stake, would, out of false modesty, have declined requesting those securities from the Board for the protection of them? and whether his not desiring them to be locked up, did not manifestly shew, that he then thought his Time-keepers equally secure without, as with those restrictions? I readily admit, that his not insisting upon any checks being imposed upon the Doctor, in the course of the trials of his Time-keepers, did not arise from that motive; nor do I mean to say, that, in my judgment, he did not act very wrong in this respect, as indeed was the opinion of many of his friends at the time; and, in spite of the Doctor's scepticism as to Admiral Campbell's opinion of the superior merit of my Father's Time-keepers, I must inform him it is a fact, which can be proved by witnesses of the greatest respectability, that the Admiral often condemned my Father for his imprudence, in leaving his Time-keepers so entirely to the Doctor's mercy, without any check or controul whatever. But I believe myself, that the real state of the case was this, that my Father felt the influence of a conscious pride, which is not unfrequently found to attend the minds of men of true genius; and, in contradiction to what the world would reckon

kon proper attention to the dictates of prudence, and a due regard to his own interest, was determined, that if, when he had done what he was satisfied was of considerable benefit to the public, the public would not take care that fair and proper measures were pursued to determine the merit of his labours, he would not take it upon himself to prescribe the restrictions necessary for this purpose. This may be deemed either a lame or romantic apology for my Father; but however much it may impeach his prudence, as I really believe it to be the true one, I shall give it, and let it speak for itself.

The Doctor afterwards proceeds, p. 80, to deny that he had, after the year's trial had closed, said, that both the Time-keepers had gone within the limits of the Act; and in the same page makes the following observations:

“ The Watches having gone within the
 “ greatest limit in the first six months trial,
 “ and seeing nothing by a general inspection
 “ of the daily rates to shew they had erred
 “ more in the second six months, and *wishing*
 “ *well to the Time-keepers*, I was, from the principle *that we easily believe what we wish*, led
 “ to believe, that they had gone within some
 “ of the limits throughout the period of the
 “ trial. I was induced to mention what I
 “ then

" then believed, without having made the cal-
 " culations to ascertain the matter, *out of good*
 " *will to Mr. Mudge*, that he might take the
 " advantage of cleaning his Watches, pre-
 " vious to such further trial as they might
 " become entitled to, if my opinion of their
 " good performance should be verified upon
 " calculation." What are the sentiments that
 may arise in the breasts of others, when they
 read this passage, I cannot say; but I must
 confess with respect to myself, that while I
 feel every disposition to reverence a man,
 whose fair and open conduct manifests his
 integrity and honour, I hope I shall always be
 inclined to testify my disapprobation of any
 person, who, by dissingenuous and uncandid
 assertions, endeavours to impose upon the cre-
 dulity of his fellow creatures. Referring the
 Reader, therefore, to p. 67, where I have fully
 proved, that the Doctor, after the year's trial
 had closed, *did* assert, in the most positive and
 unqualified manner, and without any refe-
 rence to future calculations, that both the
 Time-keepers had gone within the limits of
 the Act; and having also shewn, that the de-
 sire he expressed to have the Time-keepers
 taken away to be cleaned, is no proof of
 friendship, but that, when all that passed upon
 the occasion is taken into consideration, there
 is

is strong reason to presume the contrary; I shall content myself with making a few remarks upon the remainder of the passage: and I cannot help saying, that I am entirely at a loss to conjecture in what manner the Doctor had determined to apply his rate to shew the errors of the Time-keepers, at the time to which it relates; for from his speaking of the first and second six months as the distinct periods in which he was to find out the error, it does not appear, as if he, at that time, had intended to apply the rate to six several periods of six months each by dropping a month successively till he had got all those periods; for, if that had been his original intention, there was no necessity for him to have waited till the whole year's trial was expired, in order to have known the result upon the greatest part of the periods; but as there wanted but a fortnight of the whole year, when the Board of Longitude met in June, he might have found the result of five of them before the meeting; and as he now pretends to shew, that in four of these five periods both the Time-keepers exceeded considerably the limits of the Act, it was quite unnecessary to wait till the whole trial was complete to know whether they had gone within them: and as, by changing the periods, each distinct period is composed, partly of the
months

months in the first half year, and partly of the months in the second half year, I really do not know what he means, when he speaks of the second six months, as a distinct and separate period, to which he was to look, to see the amount of the error; unless he considered it at that time, as a period from which the sum of the daily rates in the first six months was to be subtracted, and that their difference would constitute the error. If that was the case, it amounted to nothing more than a comparison of equal periods, or in other words applying a daily rate taken from a period of equal length with the one to which it was intended to be applied, which is what I have been all along contending for the propriety of; and this method of determining the error will shew the Time-keepers to have gone exactly as the Doctor after the end of the trial declared they had.

It may be said on behalf of Dr. Maskelyne, that if he had only got the amount of the daily rates, and had not by his monthly mean rate calculated the amount of the error from day to day, as appears in the column headed "Error" in the Register printed at the end of my Narrative, it would not have been an easy matter for him to come at the result upon the several periods of six months; but this I do
not

not allow to be true; for with the column of daily rates only, which the Doctor must necessarily have had, though I really never had any thing to do with calculations, till this business of my Father's has made me pay some attention to them, I would, in the course of a morning, both have come at the daily rate of the first month, and by the application of it to as many periods of six months as the length of the trial would have admitted of, have obtained the results upon each of them. But if the Doctor thinks it was not necessary, that he should at that time give himself this trouble, but that he was at liberty to play with the feelings of another, who had so great an object at stake, just as he might think proper, I must confess our opinions differ widely.

In reply to what the Doctor has said in defence of his having let the Time-keepers down at the end of the year's trial, and having suffered them to remain so for near six months, I shall observe, that as the Commissioners before they decided that the reward was due to my Father, were to pronounce that his invention was generally practicable and useful, they ought to have had the benefit of this additional time to have enabled them to form a more accurate opinion of their general merits. Nor would my Father, as the Doctor supposes, have

had any reason to object to it; for as the time we are speaking of did not constitute any part of the year's trial, there would have been no sufficient ground for rejecting them, if they had not gone exactly within the limits of the Act; and if they had, the favourable opinion entertained of them in consequence of the accuracy of their going during the year's trial, would have been so confirmed by it, that the Commissioners would not perhaps have thought it necessary to have directed such additional trials, as they might have thought proper to have ordered, to have been continued for so long a time as they would otherwise probably have done.

The Doctor after this proceeds to a great deal of what he may call very nice and accurate reasoning on the subject of rates, and doubtless of a very different nature from my dark and laboured explanation, as he is pleased to call it, which, as he tells us, he can hardly trace a ray of light through it, may be thought to amount to *darkness visible*. I shall, however, just mention to him, that such of my friends, as I have talked to respecting the passage in question, have not been able to discover any difficulty in it; if therefore the Doctor requires more light than the rest of the world, the fault is in himself, and not in me. But as I really

really fear I should swell my Reply so much, as to tire my Readers before I got half through with it, were I to attempt a laboured confutation of all the Doctor has said on the subject of rates; and as it appears to me, he has in fact advanced nothing, which at all invalidates the reasons urged in my Narrative for taking a rate, deduced from a period of time equal to that it is to be applied to, I will only say, that if the Doctor has convinced the philosophical, and *enlightened*, part of the world, I have not the vanity to suppose I can alter their opinion. But as he mentions some circumstances which appear to me rather singular, I will take the liberty of making a few observations upon them, from an idea that the minds of philosophical men, may not be so absolutely settled by his clear, and perspicuous, reasoning on the subject, as he may possibly imagine.

The Doctor sets out with telling us, that, as the Act of Parliament makes no mention of a rate of going of Time-keepers, the allowance of a rate is an indulgence. But in this position he is totally wrong, and shews, that he has entirely misunderstood the plain meaning of an Act of Parliament, with which he has been conversant more than seventeen years. The legislature has directed, in words

as easy, and intelligible, as language can make them, that, if the method proposed shall determine the longitude within certain limits, the inventor shall be entitled to the reward : and has laid down no rules for the manner of the determination, but has only provided, that the method shall be generally practicable, and useful. The only question therefore is, whether the longitude can be determined within the limits prescribed by the Act by a method generally practicable and useful, and not whether the allowance of a rate constitutes a part of that method. But if that happens to be the case, the inventor is intitled, under the Act, to have it made use of as a constituent part of his method, which would be imperfect without it ; and is not bound to ask it as a favour. The Doctor is therefore mistaken in thinking it an indulgence, which is, in other words, supposing, that the Commissioners would be at liberty to disallow it, and by that means deprive the inventor of a part, and perhaps of an essential part, of his method. But, independent of what may be considered as the meaning of the Act of Parliament, if the only object was to ascertain the goodness of the Time-keepers, it is manifest, that a rate must be used for that purpose, even if they were perfection itself ; for if they
were

were absolutely perfect in their construction, as, upon the common principle of the infinite divisibility of matter, no human hand could possibly give the regulator the precise turn requisite to enable it to keep exact time, the difference which would unavoidably happen, must be compensated for by the adoption of a rate. But finally if the allowance of a rate really was an indulgence, as the Doctor pretends, the indulgence, which his kindness prompts him to bestow upon those who are the objects of his favour, must after all be admitted to be of a very extraordinary nature, for in the case of my Father it has done him more injury than service, as his Time-keepers would have appeared to have gone much better *without* the rate he has thought proper to make use of than *with* it.

We are next informed, p. 85, that a rate should not be taken from any long time, as three, four, five, or six months, because the Time-keeper may be liable to alter its rate of going in such a length of time; in proof of which assertion the Doctor gives us a reason, which unfortunately for him proves the contrary; for he tells us it should not be done, because, in a length of time, the Timekeeper may be liable to alter its rate; but this is the very reason why it should be done, for if the Time-keeper

keeper from time to time varies its rate, an observation of its going continued during a period of time equal to the period to which the rate is to be applied, will bring us nearer to its mean variation, and consequently the rate deduced from it will be much more useful, than if the observation of its going be continued but for a small portion of time, and the rate deduced from it be applied to a large one. It will likewise be evident upon the principle of the Time-keeper varying its rate in a length of time, that the period, from which the rate is taken, ought not only to be as nearly of an equal duration as possible with that to which it is to be applied, but ought also almost immediately to precede it; for if it happens to be remote from it, the variation, which will have taken place in the interval, will prevent us from forming any judgment whatever of its future going, from the rate; and if it should have varied from *plus* to *minus*, or the contrary, the rate will be absolutely prejudicial, and deceive those who use it. Nothing, indeed, can more fully expose the Doctor's method of taking a rate from the first month to apply to the whole year, than his own reasoning upon the subject: and what he says afterwards of the deducing the rates of Time-keepers from their going during the first month, being analogous to the manner

manner in which they are likely to be used, when sent on voyages, has just as little foundation for it. Is it to be supposed that any professional man, after going from London to Madras in four months, and staying there an equal time, would, upon his homeward-bound voyage, make use of a rate deduced from a short period of time, during which the Time-keeper was observed before he left England; when, as the Doctor himself remarks, it would be extremely probable, that the Time-keeper in the mean time had varied its rate, and consequently that the former rate would be fit only to mislead and deceive him? Would he not rather deduce a rate from his own experience of its going during his stay at Madras, or during the whole time it had been in his possession, which the slightest consideration would shew him must be much more likely to be serviceable? The same reasoning applies still more forcibly with respect to shorter voyages, where the opportunities of ascertaining the variations of the Time-keeper would more frequently occur. Hence it follows too, that if the navigator should not happen to be able to get his Time-keeper finished, or repaired, soon enough to be able to get trials of its rate of going for a longer time than a month, or perhaps a few days, as the Doctor tells us has sometimes

sometimes been the case, he would only be obliged to make use of the imperfect rate obtained from so short a trial, till he made the first land of which the Longitude was known, which would immediately enable him to substitute a better one, founded upon his own observation, in the room of it: and this operation he might repeat, from time to time, whenever he had an opportunity of ascertaining his longitude by any other means; so as never afterwards to be obliged to have recourse to a rate taken from a period of time either too short, or too remote, from that during which he used it. The inconvenience likewise could not be supposed to happen frequently in the navy; for if the Time-keepers were generally used on board his Majesty's ships, Government with the same foresight with which other matters relative to that service are conducted, would of course always have some of them under trial, which would entirely obviate the objection, as far as it applies to the navy.

The Doctor then says, "A third reason in favour of his method is, that it is a very *fair* one, and therefore proper to be adopted as a general principle, because it is made without any consideration, whether the rate so reduced from the first month shall be more or less favourable to the Watch than any other rate that might

might be deduced from the trial of the watch." But I conceive it is no argument for the method which the Doctor has used, to say it has been adopted without considering whether it is favourable or unfavourable, since the same reason might be urged for a method adopted at random without any consideration at all. The proper way of shewing a method to be a fair one is to make it appear, that after due consideration and attention, it has been found to be a method calculated to do justice, which the Doctor's method is not; and as it is manifestly unfavourable to Time-keepers, one cannot help suspecting, that he did not adopt it without considering which way it was likely to operate, though he pretends that he did. Besides, it is not very consistent with what the Doctor had said but just before of a rate being an *indulgence*, to tell us now, that his rate was adopted without any consideration whether it was favourable or unfavourable.

In answer to what the Doctor says, about his being able to deduce the errors of the watch in six different periods of six months each, as if this was the only rate that would enable him so to do; I have to observe, that the rate taken from the whole year would enable him to do so as well as his own rate, and would at the] same time enable him to discover

the errors of the Time-keeper with much greater accuracy: and there are several other rates by which it can also be done.

In p. 87, it appears to me, that Dr. Maskelyne convicts himself. He tells us, that Mr. Harrison, on his return from his Jamaica voyage, "claimed the allowance of a rate, which he deduced from nine days observations of equal altitudes of the Sun made at Portsmouth, previous to the voyage;" and gives, as one of the reasons why he objected to it, "*That the observations had not been continued long enough.*" Here he allows, that a rate taken from nine days, to be applied to a six weeks voyage, was not a proper one on account of the shortness of the time in which it had been obtained, though that time was more than a fifth part of the whole voyage; and yet pretends, that a rate taken from a month, which is only a sixth part of a six months voyage, is not only the most proper rate for such a voyage, but is likewise a proper one to be made use of even in a trial of fifteen months, to which he tells us, with seeming satisfaction, that he has applied it. The Doctor, however, does not appear to have any fondness for considering the relative proportions, which different periods of time bear to each other, but applies his universal standard to all periods alike.

The Doctor afterwards tells us, that though he used a comparison of periods of six weeks as to Mr. Harrison's Watch, as an easy, and favourable, method of shewing its errors; yet that Mr. Harrison objected to this calculation, and wished the same method to be used as the Doctor has used with respect to my Father's. But in this the Doctor is mistaken, for if he will turn to the fourteenth page of Mr. Harrison's pamphlet, he will find, that Mr. Harrison proposes, either to deduce a daily rate from the first "tranquil six weeks his Time-keeper had," and to apply that rate to the succeeding periods of six weeks, which is taking the rate from a period equal to that it is to be applied to; or to deduce the daily rate from the whole time during which it was under examination, which I have also suggested as a fair and useful method. The Doctor is mistaken also in supposing, that the method proposed by the Board of Longitude in the case of Mr. Harrison, and which he quotes as a precedent, is an authority for his own; for the period they proposed to deduce the rate from, was to the period to which it was to be applied, as 2 is to 3; whereas the period the Doctor takes his rate from, is to the period to which it is applied, only as 1 is to 6; the one therefore bearing a very considerable proportion to the time

it was applied to, and the other a very trifling one, the former can be no authority for the latter. Nor does it follow that they are upon the same principle, because they are both settled from observations made previous to the subsequent trial, which is not the point in dispute, when in fact they differ in the most essential point of all, that is, in the proportion they respectively bear to the trial. And the Doctor did not use a comparison of equal periods of six weeks, in the case of Mr. Harrison's Watch, merely because it afforded a more convenient and easy mode of calculating its errors, as he pretends, but because a period of six weeks was the length of a West India voyage, which, being the trial directed by the Act of Queen Anne, was the period to which it was to be applied. I shall prove this from the Doctor's own words. In p. 20 of his Account of the going, &c. of Mr. Harrison's Watch, he says, "Hitherto I have only shewn
 "the rate of the Watch's going from day to
 "day; I shall now give an account of its
 "going for a period of time, and shall fix upon
 "that of six weeks which is generally reckon-
 "ed the time of a West India voyage the only
 "one in which the Watch has hitherto been
 "tried," and assigns no other reason whatever. The Doctor afterwards tells us, that there was
 no

no reason for him to enter into a dispute with Mr. Harrison about the rate of going of his Watch, when this method, " which he thought Mr. Harrison could not object to, as being *favourable* to him, was sufficient to prove the imperfection of the Watch." It is rather remarkable, that all the Doctor's *favours* should be sentences of condemnation. That he should establish two opposite rules of judging, to condemn two different candidates, is sufficiently surprising in itself; but that he should endeavour to make each believe he is doing him a *favour*, is the most extraordinary thing of all, and puts one very much in mind of certain magistrates in China, who after having inflicted the bastinado upon any one who has happened to incur their displeasure, insist upon his considering it as a kindness, and oblige him to return them thanks for the favour they have done him. What opinion Mr. Harrison entertained of the favour the Doctor intended for him, and how far he thought himself obliged to him, the Reader may form an idea of from the following passage in his pamphlet, p. 15. " Mr. Maskelyne having shewn from the result " of his calculation (which I have here proved " to be false) that the Watch is not to be depended upon to determine the Longitude in " a voyage of six weeks," then says, " these
 " considerations

" considerations are sufficient to explain the
 " motives which might have actuated Mr. Har-
 " rison, as a man of *prudence*, in desiring to
 " send his Watch two voyages to the West In-
 " dies, upon his idea that he should be entitled
 " to the large rewards prescribed in the Act of
 " the 12th of Queen Anne, in case his Watch
 " kept time within the limits there mentioned,
 " whether the method was or could be ren-
 " dered generally useful and practicable, or
 " not; this insinuation (published under the
 " authority of the Commissioners of Longitude)
 " that I had contrived a trial which I knew
 " the Watch would fulfil, whilst I was con-
 " scious that it would not answer the general
 " purposes of the Act of Queen Anne, and
 " consequently that I had formed a villainous
 " scheme to rob the public of the reward
 " without really and effectually performing
 " the conditions, strikes me as a charge of so
 " atrocious a nature, that I think myself not
 " only *justified* in publishing to the world what
 " has been done with respect to trials of the
 " merit of my invention, but even *indispensably*
 " *obliged* so to do. I well know what I hazard
 " thereby, and if the rest of my reward cannot
 " be obtained on principles of *national faith*
 " and *public spirit*, I am contented to forego
 " it, but I will not descend into the grave
 " loaded

“loaded with the dishonour which my ene-
 “mies, availing themselves of their rank or
 “offices, have, in various ways, attempted to
 “throw upon me.”

The Doctor urges, p. 92, that Mr. Harrison's was a particular case, very different from my Father's, and that similar modes of calculation could not therefore be adopted with any degree of propriety. Mr. Harrison's, however, was no more a particular case in this respect than my Father's; for if Mr. Harrison's was a particular case, because the Act of Queen Anne had prescribed a voyage of six weeks as the time of trial, my Father's is just as much a particular case, because the Act of his present Majesty has prescribed a trial of six months: and there is no reason, why, if the time of trial is lengthened, the time for ascertaining the rate should not be lengthened also; particularly when, as I have shewn before, an extension of the time for ascertaining the rate is most likely to make the rate itself useful, which has been repeatedly confirmed by practice. I agree with the Doctor, that the circumstances of the cases ought to be attentively considered, and have followed his advice: but the Doctor's reasoning is not strictly logical, when he says, “that it does not necessarily follow from analogy,

logy, that because it was proper to compare the going of Mr. Harrison's Time-keeper in successive periods of six weeks together, it would therefore be proper to make comparisons between periods of six months with Mr. Mudge's Time-keepers, for that inferences from analogy have not the force of direct demonstrations;" it being no proof that a thing does not necessarily follow from analogy, to say that inferences from analogy have not the force of direct demonstration; inasmuch as many things which have not the force of direct demonstrations, do notwithstanding necessarily follow from analogy. However, I shall not differ with the Doctor about words, and therefore shall only observe, that though inferences from analogy have not the force of direct demonstrations, yet we must be contented to reason from analogy, till we have some better guide; and the Doctor has not as yet favoured us with any thing like a demonstration, either that his own method is a proper, or that mine is an improper, one; though I think I have advanced, what at least makes very near approaches to a demonstration, to shew that the rate I have contended for, and which the Doctor himself formerly used, is much better calculated to discover the future

ture going of a Time-keeper than that which he is at present an advocate for.

As the Doctor has stated nothing in pages 94 and 95, but what will be found upon an attentive consideration to tend invariably to the conclusion, that a short period of time ought not to be applied as a standard to a long one, I shall pass to page 96, where the Doctor, after having stated, that my argument seemed to depend upon a supposition that the space of one month is not sufficient for the Watch to run through the period of its irregularities, but that six months are; tells us he cannot see the grounds of this supposition. The fact is, that I never made the supposition that six months are sufficient, or insufficient, for a Time-keeper to run through the periods of its irregularities; having never undertaken to define the time in which this would happen, as it must necessarily vary under different circumstances. My argument, in reality, only went to shew, that a large period of time ought to be made use of in preference to a small one, which I still insist upon, as it is better calculated to give a mean of this variation, and is therefore more fit for use.

When the Doctor speaks of the causes of error in watches being fortuitous, and vague, in their nature, and not defined as to their

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quantities

quantities and modes of operation ; and also, that a knowledge of them will *for ever* elude the researches, as well of the Philosopher, as the Watch-maker, I cannot but admire what he says. Many, however, of the most considerable causes of error, which formerly belonged to Time-keepers, have been discovered and removed within the present century ; and there is no reason why we should conclude, that those which remain may not be discovered, and obviated, at some future period. And though I freely confess, that I am neither a Philosopher nor a Watch-maker, I cannot help thinking, that I can mention some causes of error, which still remain, that do not seem so subtle in their nature as entirely to elude our researches. It appears to me that the different temperature of the weather, and the difference in the density of the air, at different times, will go a great way towards finding out the causes of many of them. For though there be a compensation, or thermometer, to provide against heat and cold, yet as Dr. Maskelyne admits, that the perfect regulation of it is a *most difficult thing to accomplish*, we may well ascribe a considerable part of the error which still continues to exist in the best Time-keepers to this cause ; and when it is considered how much has been already done in this respect, it is fair to conclude, that

that the future discoveries of men of genius will from time to time suggest further improvements, by which it will be still more diminished. It is well known, that the best watch in the world, in every other respect, would, from the contraction and expansion of the metals, of which it is composed, vary near six minutes between a hot summer day, and a cold winter day, if there were no thermometer; but the thermometer is, at present, brought to so great a degree of regularity of adjustment, that a very good Time-keeper with one, is not liable to be affected more than two or three seconds, which is not a hundredth part of what the error would be without such a provision*. Besides the differ-

* My Father has within a few days told me, that, after he had applied the thermometers which are now contained in his Time-keepers, he discovered from the effect of them, that there were certain points of heat and cold, which they were not an entire provision against; but Dr. Maskelyne may possibly be a little puzzled, when I tell him these points are not the extremes. However, my Father said he immediately saw the reason why they were not, and his mind suggested a principle which might be applied as a remedy; but as the proper application of it depended upon a course of experiments, he found himself too much worn out by the increasing infirmities of old age to be able to carry them completely into effect; though he had actually begun them, and had proceeded so far, as to ascertain that they were capable of answering the purpose.

ence occasioned by the operation of heat and cold upon the metals, another cause of error arises from the oil made use of in Time-keepers, the state of which is continually altering according to the fluctuations which take place in the temperature of the air, becoming more or less fluid, in proportion as the weather is hotter or colder; and this of course will contribute its share to the variations observed in the going of the Time-keepers. Moreover the different density of the medium in which the wheels move, which is in a state of almost perpetual fluctuation, will also, it is reasonable to presume, occasion a proportional fluctuation in the going of the Time-keeper. Though it may not, at present, be very easy to ascertain the quantity of variation, which will take place from time to time in consequence of the agency of these causes of error, it seems to me we may give a shrewd guess at the modes of their operation; and as experience shews us, that the effect of the most considerable of them has been already confined within very narrow limits, we have no just reason to suppose, that the others will *for ever* so entirely elude the researches of the Philosopher, or Watch-maker, as to prevent him from obviating their effects, as far as any purposes of general utility can demand.

What

What the Doctor observes, almost immediately afterwards, of Time-keepers, and my Father's in particular, having been found liable after a length of time to accelerate, or retard, their rates of going, and which, he informs us, is particularly adverse to the principle of taking the rate of a Watch from a long space of time previous to the intended trial, lest the rate may have become changed for a very different one, is, as I have observed before, the strongest argument that can be used to prove the absurdity of taking the rate from a single month, to apply to all the periods contained in the following year; for if there are considerable alterations in the second six months, which the first six months do not partake of, how much greater may the variations be supposed to be in the whole of the last *eleven* months, of which the first single month will have no part.

The Doctor then produces some examples to prove, that my principle of taking the rate of a Watch from a period of time equal to the going afterwards is not a just one, which, like some of his arguments above noticed, unluckily prove the contrary; for he shews by them, p. 97, that the Watch Blue varied by my method 1' 16" more than by the method he there makes use of himself, but the Watch Green
varied

varied 3' 10" less by my method than by his. The result therefore upon the whole is 1' 54" against him. And it is reasonable to presume, that the difference would have been still greater against the Doctor, if he had followed up his principles fairly, which he has not done in the instances he has given, though even *they* have turned out unfavourable to him; for having first compared several periods of six weeks with the six weeks immediately preceding each of them, he afterwards compares the same periods with the week immediately preceding each of them, and then makes a comparison of the results obtained by the first method with those obtained by the second. It would be offering an affront to the understanding of the Reader to suppose, that he does not immediately perceive, that the second of these methods both actually, and proportionally, differs materially from the plan the Doctor originally pursued in the trial of my Father's Time-keepers; for it is obvious, first, that no week, which the Doctor here makes use of, is applied to more than *six* of the weeks which follow it; whereas according to his former plan the first month was applied to all the succeeding *eleven*; secondly, that, according to this new method, no week is more than *five weeks* distant from the last week it is applied to;

to; whereas, according to the plan for mery made use of, the first month was *ten months* distant from the last it was applied to; and, thirdly, by the Doctor's new method, a different standard is applied to every period, taken from a period immediately preceding it; whereas by his former method the same standard was applied to *all* the periods, and of course the period from which it was taken immediately preceded only the first of them. The Doctor has therefore not only failed in proving his point, but has shewn not a little unfairness in his *attempt* to do it.

We are next presented with some observations, p. 98, as to the propriety of comparing the two successive periods of six months with each other, and considering the difference as the error; where the Doctor says, he believes no person but myself would have thought of it. This observation, however, is rather a little extraordinary, because his own comparison of periods of six weeks in the case of Mr. Harrison's Watch, is exactly the same in its nature; and I have particularly dwelt in my Narrative on the circumstance of his having used it, as a reason why equal periods ought to have been also compared in the trial of my Father's Time-keepers. The objection, that we are tied down by it to a single calculation,

lation, which can give but little information concerning the steadiness or unsteadiness of the going of the Watch in the course of the twelve months trial, while his method clearly ascertains that point, has no force in it, if that calculation be the proper one; and if the only object be to ascertain the steadiness or unsteadiness of the Watch during any of the intermediate periods in the course of the trial, I trust the Reader is convinced, from what has already been said, that a daily rate deduced from the going during the whole year, and which of course gives the mean of all the variations, is a perfect mode of ascertaining its deviation from its mean rate of going, or, in other words, its steadiness or unsteadiness during any given period, and that the Doctor's method is not at all fit for the purpose. And with respect to what the Doctor says, at the close of the paragraph, of Watches accelerating or retarding their rate of going after a length of time, I have shewn several times already, in answer to his frequent repetitions of it, that it concludes most forcibly against the method he has adopted.

As to what is said, p. 101, of the Time-keeper Blue, by the use of the method I contend to be the proper one, having only gone "within $4\frac{1}{2}$ " of 4', the most extended limit of
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the Act," and "of my having made all this mighty stir about this small difference," I answer, that if the Time-keeper had only gone within one second of the limit, or, to speak more accurately, only one second within the limit, my Father would have so far complied with the Act; and when it is considered that this small difference, as the Doctor calls it, was to make a difference to my Father of 5000 l. the Public, I am persuaded, will be convinced, I have not made all this stir about nothing.

The Doctor then comes to his strong hold, where he affects to triumph, not a little, on his having found out, that according to my own mode of calculation, applied to the Watch Green, it had not gone throughout the second six months within the limits of the Act. He says, "Mr. Mudge may say, if he please, as he has said before, that I have contrived to make such calculations as to make it appear, that the Watch had erred beyond *any* of the limits of the Act." Now I assure Dr. Maskelyne, when I find a charge made against me to be a true one, I have not the least inclination to dispute it. I freely confess then, that Dr. Maskelyne has shewn, that by applying a rate taken in pursuance of my mode of calculating the going, it will appear, according

to his Register, that the Watch Green has not gone in every part of the second six months within the limits of the Act; but that on the 128th day of that six months, it appeared to be two seconds and a half beyond the limits; and that therefore, according to the Register, the Act has not been complied with. But I cannot help thinking, that the strength, which this discovery would have given to the Doctor's case, must be somewhat weakened by his speaking of the Time-keepers in another part of his Book, and telling us, p. 126, that he had shewn, even according to my own calculations, *they* had erred beyond all the limits of the Act. However, if my Readers will have the goodness to look to p. 103 of the Doctor's Answer, they will find he has only shewn that the Watch Green had exceeded the limits, which was the only one he could make appear to have done so; and it is to no purpose to say, that the Act does not give the reward, unless both go within the limits; for that would only have justified him in stating, that, as both had not gone with the requisite degree of exactness, my Father was not entitled to the reward for either of them; but by no means gave him a right to say, that *they*, by which is meant both of them, had gone beyond *all* the limits of the Act, when one had gone

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confessedly within them. And I imagine there are few persons, who will not be inclined to think the Doctor knew this to be the case, when they see, upon the face of his Answer, how industriously he has been employed in making calculations.

But though I allow, that one of the Time-keepers has not gone within the limits, according to Dr. Maskelyne's Register, yet whether it has *in reality* exceeded them or not, must depend upon the truth of his numbers. And notwithstanding the Doctor congratulates himself upon my not having called their authenticity in question, if he will take the trouble to look over my Narrative with attention, he will find that I entertained very considerable suspicions of them, upon grounds that sufficiently warranted the distrust I expressed. The reason I did not impeach them in direct terms, was, that though, from the Time-keepers going, even under more unfavourable circumstances, so very much better, both before, and after, the Doctor's trial of them, than they did while in his possession; added to many other remarkable circumstances of which an account has been already given; I had the strongest reasons to suspect, either that they had met with improper treatment at the Observatory, or that the Register did not con-

tain a true account of their going; yet, as the daily comparifon of them with the clock, the regulation and management of the clock itfelf, and the making entries in the Register of the variations obferved, were wholly in the Doctor's power, and performed partly by himfelf, and partly perhaps with the affiftance of fome one of his immediate dependents, in confequence of which, particularly when it is confidered that the obfervations were made to a quarter of a fecond, variations different from thofe really obferved, to the amount of much more than two feconds and a half altogether in 128 days, might at particular times very eafily have paffed for the real ones, and have found their way into the Register, with fcarcely any chance of their being difcovered or known, except by the perfon who occafioned them; it was impoffible for me to be furnifhed with any pofitive evidence of the fact, though ftrongly indicated by all the concomitant circumftances. For this reafon, after having fhewn in my Narrative, that the Doctor was an enemy to the fuccefs of the Time-keepers, and had, in order to prevent their fuccefs, had recourfe to many very unfair and improper practices, I left it to the Reader to draw his own conclufions. Having now ftrengthened, and confirmed, what I there advanced, by additional

ditional facts, proving, upon the most unquestionable testimony, and sometimes from the Doctor's own words, that he has been a confirmed enemy to the Time-keepers, and has supported his opposition not only by the most uncandid, and disingenuous, conduct, but frequently by round and bold assertions, which he must have known at the time not to be true; I again submit it to the Public to form their opinion of the degree of credit due to his numbers, and of the kind of treatment the Time-keepers may have met with while under his management; having no doubt that after an attentive consideration of the circumstances, their decision will be such as the real justice of the case requires.

I shall now proceed to vindicate the rates mentioned in p. 29, and 30, of my Narrative, from the Doctor's misrepresentations. He says, p. 104, of his Answer, that
 "the first method seems preposterous, to
 "take so important an element of the calculation from the two worst goings of all, especially if it be considered, that an error of
 "only one second in the assumed daily rate
 "will produce an error of three minutes in the
 "computed going of the watch in six months;
 "that the last method is very favourable to
 "myself, because let the Watch go ever so ill,
 "it

“ it will just take off half the error; and that
 “ both methods are liable to this insurmount-
 “ able objection, that they are impracticable in
 “ the case of a sea voyage, because the proposed
 “ rate could not be known till the voyage was
 “ over, and consequently could be of no use in
 “ the voyage.” If the Reader will turn to
 the 29th page of my Narrative, he will see, that
 the first rate mentioned is the mean between
 the greatest gaining and losing of the Time-
 keeper in six months, which is proposed to be
 applied to the *next* six months. It is not true,
 therefore, that this rate could not be known
 till the voyage is over, for it is expressly
 proposed to be taken from a preceding pe-
 riod, and applied to a subsequent one. And
 with respect to the taking of a mean from the
 two worst goings of all, which the Doctor calls
 preposterous, I answer, that the taking of a
 mean between the two extremes is, as the
 Doctor very well knows, no new principle even
 in Astronomy. It is true, that if the Time-
 keeper varies much from itself, that is, if it
 departs much from perfection, the error will,
 as the Doctor observes, appear enormous, by
 the application of this rate; which shews clearly
 that it was not taken notice by me merely be-
 cause it was *favourable*. After all, I have not
 mentioned this rate, as the most proper one,
 nor

nor even delivered any opinion of it at all ; but only stated it as a rate, " which some persons had suggested," and then shewed, that *if* it should be considered as a proper one, both my Father's Time-keepers, by the application of it, would be found to have gone within the *strictest* limits of the Act. As to the second rate, which Dr. Maskelyne makes the subject of his animadversions, namely, the one taken from the whole year and applied to any intermediate parts of it, I have already made some remarks, p. 57, upon his strange assertion, that, let the Watch go ever so ill, it will just take off half the error, which I have there proved to be totally ill founded.

What the Doctor observes, p. 104, where he speaks of my *curious* inconsistency, in finding fault with him for using two different methods, though on two very different occasions, and at the same time making use of three different methods in one and the same case, is so extremely curious in itself, that I cannot avoid taking some notice of it. As the Doctor here quits the line of direct demonstration, and condescends, at last, to reason from analogy, it is rather remarkable he did not discover, that no principle of analogy would bear him out; for, to have convicted me of inconsistency, he ought to have shewn, that his own use of

two different methods on *two different* occasions, for which he says I have blamed him; and my use of three different methods on *one and the same* occasion were parallel cases, which they are not, as is evident, from the bare statement of them : but their difference will appear still more striking, when it is considered, that the Doctor's methods are two rules, extremely different from each other, for determining the merits of machines made to measure time, and that by the use of the first of them, at one time, he has rejected one machine, and by the use of the second, at another time, he has rejected another ; whereas the methods, I have proposed, are all made use of, as the Doctor observes, upon one and the same occasion, and all concur in proving one and the same thing, which is, that the Doctor's second method of determining the merit of Time-keepers is an exceedingly bad one. If I had ever acted in the capacity of a public judge, and adopted two opposite rules of determination, that, by the arbitrary use of either, I might have been sure to condemn all who had the misfortune to be brought before me, there might have been some foundation for the Doctor's argument : but at present there is no resemblance between the cases whatever.

The

The Doctor afterwards says, that I only shew my sense of the imperfection of my Father's Time-keepers by endeavouring to withdraw them from *his* method of examining them. But if that method be an improper one, and calculated to shew apparent errors, where there are no real ones, as I have sufficiently proved, my withdrawing them from such an examination, only shews my sense of the imperfection of the Doctor's method, and not of the imperfection of the Time-keepers.

Though I wish not to say any thing of a character so deservedly admired as Mr. Harrison, that may be thought in the least disrespectful *; yet in reply to what Dr. Maskelyne says

* As this may perhaps be the last time I shall have occasion to mention Mr. Harrison, I cannot help paying that tribute of respect which is due to his memory, by laying before the Public the sentiments of great candour and impartiality which he has expressed in the following passage—" It is with reluctance that I follow Mr. Maskelyne into a subject in which I may seem like him to be actuated by a selfish preference to my own scheme; however as I shall give my reasons for what I advance, I will not hesitate to submit them to the public. I beg to be understood as a warm and declared friend to that [meaning the Lunar method] and every other mode which can be devised of ascertaining the Longitude at sea, so long as they keep within the bounds of reason and probability. Here are now two methods before the Public; would to God there were two hundred! the

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says of the declaration Mr. Harrifon made, that the rate of his watch could be accurately discovered in three hours, I must say, that it is well known that gentleman was in this respect mistaken, which has been since fully proved by experience.

In like manner, Mr. Harrifon, knowing the superior excellence of the principles upon which his Time-keeper was constructed, and not considering the agency of certain fluctuating causes, that would constantly produce error, once observed, that if it went at all, it would go right; upon which declaration Admiral Campbell, after the return of the Time-keeper from a voyage, in which it had committed a certain quantity of error, laughingly observed, that though it had in fact been going during the whole voyage, yet as it had not gone perfectly right, it had not gone at all.

What Dr. Maskelyne says, p. 107, of the want of ability in persons, who carry Time-keepers to sea, to determine a rate, would lead us to suppose that the month's rate, which the

"importance of the object would warrant public encouragement to them all; but called upon to say something on the subject, I think it incumbent upon me to point out those limits beyond which its utility cannot, from the nature of the thing, be extended."

Doctor

Doctor allows us to use, is not to be departed from, even if a voyage should be of two or three years duration, which is absurd, upon the Doctor's own admission, that Time-keepers in a length of time vary their rate of going. But I should apprehend it would be really of no consequence, whether the voyage lasted three months or three years, if the persons, who were to use the Time-keepers, should in truth be unable to determine a rate; for it seems to me, that the same want of ability, by which they would be prevented from settling the rate, a thing of no particular difficulty, would equally incapacitate them from using the Time-keepers at all.

I shall next consider what the Doctor says relative to the going of the Time-keepers in the hands of Mr. Dutton, subsequent to his last trial of them. The reason he gives, p. 108, why they might be expected to go better with Mr. Dutton than with himself, viz. that Mr. Dutton's shop, in which they were tried, "is a close room, where there is a stove occasionally lighted in winter; whereas there is no fire place in the Transit Room at the Royal Observatory, nor is there ever any fire made there; and that the air of London out of doors is generally some degrees warmer than

at Greenwich ;” like many other of the Doctor’s arguments, appears extremely specious and imposing at first view, but will by no means stand the test of enquiry ; for his object must have been to shew, that in consequence of the situation of the Time-keepers in London, they were not subject to so great a variation in point of temperature, as they were at Greenwich. But this is contrary to the fact ; for whoever looks into the Registers will find, that the range of the thermometer was greater in Mr. Dutton’s shop, during his trial of them in London, than it was in the Transit Room at Greenwich, during their twelve months trial by the Doctor ; the thermometer having been as high as $73\frac{1}{2}^{\circ}$, and as low as 37° , in Mr. Dutton’s shop during his trial of them, and never higher than $70\frac{1}{2}^{\circ}$, nor lower than $36\frac{1}{2}^{\circ}$, in the Transit Room at Greenwich during their trial by the Doctor. And moreover, as in very cold weather a fire was occasionally kept in Mr. Dutton’s shop by day, when the thermometer was observed, the additional cold which the Time keepers were at such times exposed to there by night, and of which the Register of course takes no notice, must have been proportionably much greater, than in the Transit Room at Greenwich.

The

The Doctor then proceeds as follows; "notwithstanding this advantage in their favour at Mr. Dutton's," (meaning the advantage he pretends the Time-keepers had of going in a more equal temperature with Mr. Dutton, which I have shewn was not the case), "I find by a calculation of their going during his trial of them, see No. XI. and XII. of the Appendix, that the Watch Green went worse with him than with me, its greatest error with him having amounted to 8' 12" in six months, whereas with me it did not exceed 7' 4". On the other hand, the Watch Blue went better in his trial of them than in mine, its greatest error with him having been 3' 23", whereas with me it amounted to 6' 35". The going of the Watches with Mr. Dutton evidently corroborates my trial of them, as the going of the first Time-keeper with Dr. Hornsby agreed with, and corroborated my trial of it, see p. 35, 36, and 63 of this Answer;" and a little after he says, "Mr. Mudge endeavours to enhance the merit of the going of the Time-keepers in Mr. Dutton's trial, which he *mistakenly* supposed better than in mine." I am much surprised at the assertions, which the Doctor here makes; but still more so at the weakness of
of

of the reasoning, with which he endeavours to support them. It is evident he wishes to make his Readers believe, that the Time-keepers went as well during his trial of them, as they did during that of Mr. Dutton; but not one argument has he adduced to prove this, which does not as usual prove the reverse. It appears, upon his own shewing, even according to his own *erroneous* method, which for once happens to fail him, that the sum of the errors of both Time-keepers, during their trial with Mr. Dutton, amounted only to 11' 35"; whereas with him they amounted to 13' 39". But that the proof of the superiority of their going with Mr. Dutton may not rest upon so insecure a foundation, as that afforded by the Doctor's rate, I shall give the results of a variety of other comparisons, each of which proves, that their going was much better with Mr. Dutton, than it appears, according to the Doctor's Register, to have been with him; which I am inclined to think will fully satisfy the world, that the Doctor's trial is, to use his own language, as little corroborated by their going with Mr. Dutton, as his trial of the first Time-keeper was corroborated by its going with Dr. Hornsby. Indeed, if the sum of the errors of the two Time-keepers,

taken

taken together, had been equal in both trials; it is wonderful the Doctor should have supposed, that their going in the one trial was corroborated by their going in the other, when it is manifest, according to his own method, that the Time-keeper, which appears to have gone the worst with him, actually went the best with Mr. Dutton.

Comparison between periods of one month as to Green :

		Dr. Maskelyne.		Mr. Dutton.	
		Error.		Error.	
Month.					
Between 1st & 2d	-	0	11,1	-	0 53 $\frac{3}{4}$
2 & 3	-	0	22,9	-	0 5 $\frac{1}{2}$
3 & 4	-	0	35,4	-	0 0 $\frac{3}{4}$
4 & 5	-	1	6,8	-	0 8 $\frac{1}{4}$
5 & 6	-	0	34,2	-	0 12 $\frac{1}{2}$
6 & 7	-	0	13,4	-	0 1 $\frac{1}{4}$
7 & 8	-	0	10,0	-	0 17 $\frac{1}{2}$
8 & 9	-	0	19,7	-	0 12 $\frac{1}{4}$
9 & 10	-	0	20,9	-	0 33
10 & 11	-	1	28,8	-	0 25
11 & 12	-	0	55,9	-	0 12
Sum of errors	-	6	19,1	-	3 1 $\frac{3}{4}$

Comparison

Comparison between periods of one month
as to Blue:

		Dr. Maskelyne.		Mr. Dutton.	
		Error.		Error.	
Month.					
Between 1st & 2d	-	0	9,1	-	0 5 $\frac{1}{2}$
2 & 3	-	0	2,6	-	0 2 $\frac{1}{2}$
3 & 4	-	0	20,8	-	0 0 $\frac{3}{4}$
4 & 5	-	0	37,5	-	0 21 $\frac{1}{2}$
5 & 6	-	0	18,8	-	0 13 $\frac{1}{2}$
6 & 7	-	0	14,4	-	0 0 $\frac{1}{2}$
7 & 8	-	0	2,0	-	0 6 $\frac{1}{2}$
8 & 9	-	0	0,2	-	0 13
9 & 10	-	0	38,3	-	0 35
10 & 11	-	0	46,7	-	0 14 $\frac{1}{2}$
11 & 12	-	0	12,1	-	0 0 $\frac{3}{4}$
Sum of errors	-	3	22,5	-	1 53 $\frac{3}{4}$

Comparison between periods of six weeks as
to Green:

		Dr. Maskelyne.		Mr. Dutton.	
		Error.		Error.	
Six weeks.					
Between 1st & 2d	-	0	18,7	-	0 58 $\frac{1}{4}$
2 & 3	-	0	33,2	-	0 2 $\frac{1}{2}$
3 & 4	-	1	43,6	-	0 22 $\frac{3}{4}$

		Dr. Maskelyne.		Mr. Dutton.	
		Error.		Error.	
Six weeks.					
Between 4 & 5	-	0	9,9	-	0 25 $\frac{1}{4}$
5 & 6	-	0	13,6	-	0 16 $\frac{1}{2}$
6 & 7	-	0	34,5	-	0 36 $\frac{1}{2}$
7 & 8	-	2	27,0	-	0 53 $\frac{1}{2}$
Sum of errors	-	6	0,5	-	3 35 $\frac{1}{4}$

Comparison between periods of six weeks as to Blue:

		Dr. Maskelyne.		Mr. Dutton.	
		Error.		Error.	
Six weeks.					
Between 1st & 2d	-	0 10,1	-	0 1 $\frac{1}{2}$	
2 & 3	-	0 30,3	-	0 5 $\frac{1}{4}$	
3 & 4	-	1 11,3	-	0 25 $\frac{3}{4}$	
4 & 5	-	0 11,0	-	0 19 $\frac{1}{2}$	
5 & 6	-	0 3,3	-	0 4	
6 & 7	-	0 33,0	-	0 43 $\frac{3}{4}$	
7 & 8	-	0 35,2	-	0 7	
Sum of errors	-	3 14,2	-	1 46 $\frac{3}{4}$	

Comparison between periods of two months
as to Green :

		Dr. Maskelyne.	Mr. Dutton.
		Error.	Error.
Two months.			
Between 1st & 2d	-	0' 0",8	- - 1' 5 $\frac{1}{2}$ "
2 & 3	-	2 12,4	- - 0 4 $\frac{3}{4}$
3 & 4	-	0 17,3	- - 0 27
4 & 5	-	0 28,5	- - 0 40
5 & 6	-	4 14,3	- - 1 36
Sum of errors	-	7 13,3	- - 3 53 $\frac{1}{4}$

Comparison between periods of two months
as to Blue :

		Dr. Maskelyne.	Mr. Dutton.
		Error.	Error.
Two months.			
Between 1st & 2d	-	0' 16",8	- - 0' 10"
2 & 3	-	1 54,5	- - 0 28 $\frac{3}{4}$
3 & 4	-	0 8,1	- - 0 21
4 & 5	-	0 40,6	- - 0 54 $\frac{1}{2}$
5 & 6	-	1 7,3	- - 0 7
Sum of errors	-	4 7,3	- - 2 1 $\frac{1}{4}$

Comparison

Comparison between periods of three months
as to Green :

	Dr. Maskelyne.	Mr. Dutton.
	Error.	Error.
Three months.		
Between 1st & 2d -	1 36,2	1 11
2 & 3 -	2 14,6	0 35
3 & 4 -	4 6,1	2 48½
Sum of errors -	7 56,9	4 34½

Comparison between periods of three months
as to Blue :

	Dr. Maskelyne.	Mr. Dutton.
	Error.	Error.
Three months.		
Between 1st & 2d -	2 32,1	0 38½
2 & 3 -	0 35,9	0 7½
3 & 4 -	0 11,6	1 36½
Sum of errors -	3 19,6	2 22½

Comparison between periods of four months
months as to Green :

	Dr. Maskelyne.	Mr. Dutton.
	Error.	Error.
Four months.		
Between 1st & 2d -	4 41,2	0 48
2 & 3 -	3 0,2	2 29
Sum of Errors -	7 41,4	3 17

Comparison between periods of four months
as to Blue:

	Dr. Maskelyne.	Mr. Dutton.
	Error.	Error.
Four months.		
Between 1st & 2d -	3 57,7	0 46½
2 & 3 -	0 5,8	1 35
Sum of errors -	4 3,5	2 21½

Comparison between its greatest difference
from itself in twelve months as to Green.

Dr. Maskelyne. Mr. Dutton.

0 9,0 0 7

Comparison between its greatest difference
from itself in twelve months as to Blue.

Dr. Maskelyne. Mr. Dutton.

0 5,3 0 3½

The Doctor afterwards states the difference
between the rate of going of the Time-keepers
in the last month of his trial of them, and the
first month of their trial by Mr. Dutton, after
having been near six months let down and neg-
lected, which he says was 6",1 as to Green,
and 3",9 as to Blue; and also the difference
between their rate of going in the first, and
last,

last, month of Mr. Dutton's trial, which, as to Green, he says was 3",8, and as to Blue 1",1. After this he tells us, that "these variations of
 " the Watches shew, that they were not con-
 " structed upon such permanent principles as
 " I have pretended; that such variations must
 " be allowed to be of consequence, because an
 " alteration of the rate of only 1" in a day will
 " make 3' in six months; and that it does not
 " appear that the letting down the Watches,
 " and keeping them in that state should affect
 " the rate of their going when they should be
 " set in motion again; at least that it had not
 " had any such effect in the instances of their
 " being accidentally let down at the Royal
 " Observatory." To this I reply, that the alteration in the rate was manifestly occasioned by their being so long let down and neglected, and consequently is no evidence of any imperfection in the Time-keepers; but merely of the improper conduct of those who had the management of them. For it appears from the Doctor's Registers, at least as far as we can give credit to them, that the alteration did not take place previous to the letting them down; neither was it occasioned by any thing that happened to them after they were set going again; for both Time-keepers discovered it the very first day they were put in motion, and it was of the
 same

same kind in both of them, that is, an acceleration of their rate of going, which shews, that it did not arise from any fault in the Time-keepers, but from the operation of the same causes, whatever they were, acting in a similar manner upon both. And instead of going much worse afterwards, than they did before, which might have been expected, if this alteration had originated in any imperfection in their principles, both of them actually went better, in every respect, in the second trial, than they appear by the Doctor's Register to have done in the first. Dr. Maskelyne not having been candid enough to hint at any of the causes of the alteration he mentions, though some of them were sufficiently obvious, because it would have frustrated the design he had in view; but having, on the contrary, insinuated, that it was not occasioned by their being let down, I shall take care, that the Reader is not left altogether in the dark upon the subject. The alteration of temperature, though not the only cause, may be supposed to have had its share; the last month of the Doctor's trial having been in the summer, and the first of Mr. Dutton's, with which he so fairly compares it, in the winter. Accordingly, if we take the corresponding month of Mr. Dutton's trial for the comparison, we shall find the difference, after more than

than double the time, to have been more than one third less. Another cause may be supposed to have been, that a temporary change had taken place in some of the constituent parts of the Time-keepers, in consequence of their being left, near six months, in a state so different from that in which they had been during the preceding year. The springs, we know, after being left long in a state of relaxation, will act with increased force for some time after they are regularly wound up again. That this second cause operated upon them, is evident, from the Register of their going during the second year; for though they did not return to their former rate, they were gradually approximating towards it, instead of receding farther and farther from it, as might otherwise have been supposed. Their going, therefore, during the second year's trial, instead of being a proof against their being constructed upon permanent principles, as the Doctor imagines, is a proof in favour of it. What he observes, of the letting down the Time-keepers at the Royal Observatory not having occasioned any such alteration, will not bear a moment's examination, for they were never let down more than five days at a time during the Doctor's trial, at least as far as he has shewn us in the Register. As then the difference occasioned by

by their being suffered to continue in that state, for 165 days, was no more than $6''.1$, the difference in five days would not have amounted to the twenty-fifth part of a second, a quantity that could not possibly have been discovered. But the Doctor is so strangely attached to his system, of comparing small portions of time with large ones, that he seems incapable of divesting himself of it, whatever be the circumstances. With respect to the variance in the rates, which took place between the first, and last, month of Mr. Dutton's trial, I have mentioned a reason, why the Time-keepers, after being so long down, might be expected to go faster, for some time after their being set going again, than they would afterwards, which being allowed for, will of course diminish the variance. But I am by no means anxious to have this allowance made in my favour, as the variation is so trifling, that no method but the Doctor's, of which the impropriety has been repeatedly proved, could magnify it into importance. However, if the Doctor, instead of *jerking* himself from one month to another so far asunder as six, and twelve, months, had in a fair and proper manner compared the rates in periods of equal length immediately in succession, he would have found, that three out of the four comparisons of six months, which his,
and

and Mr. Dutton's, trials afford, would not have produced an alteration of the rate of even 1" a day.

As the Doctor, in addition to what he had said, p. 62, relative to Dr. Hornsby, viz. that he wished to add to Dr. Hornsby's reputation by exciting him by his example to co-operate with him in the cause of astronomy, tells us, p. 114, that he supposes Dr. Hornsby informed me of all I have mentioned, as having passed at the Board of Longitude, when they were sitting upon my Father's Memorial; that he is glad I have always had an advocate there; and that the whole of what I have attributed to him, as having said concerning the Time-keepers, is so very proper and commendable for him to have said, that though he took no notes, not expecting to have his words so minutely reported without doors, that he shall say nothing to extenuate this charge, but rather to add to it; I shall just observe, that however high the opinion may be, which the Doctor entertains of his own abilities as an Astronomer, Dr. Hornsby's reputation in the same line is already so well established with the scientific part of the world, as neither to stand in need of, nor to be likely to receive, any addition to it, from that co-operation with Dr. Maskelyne, which the latter so modestly proposes.

With respect to Dr. Hornsby having been a warm advocate for my Father at the Board, I can only say, that I know no motive he could have had for being so, but a firm persuasion that he was entitled to the encouragement he asked for, and an earnest desire to obtain for him, what he conceived to be justly his due. And though the Doctor has censured him for reporting to me, what was mentioned at the Board upon this occasion, it is not easy to imagine, how any one in his situation could easily have acted otherwise; for, having obligingly undertaken to mention a specific sum to the Board, which I requested him to do upon his informing me it was expected, it was natural for me afterwards to ask him what had been said when the question was debated: and, as the Board of Longitude was never considered as a Committee of Secrecy, and Dr. Hornsby probably judging from the liberal, and candid, sentiments, which influenced his own mind, might not be aware, that any member of the Board would say, what he was afraid of hearing of again; it was as natural for him to tell me, upon what grounds my application had been rejected. And if what Dr. Maskelyne said was so very proper and commendable, that he rather wished to add to, than to extenuate it, he is the last person who ought to be offended;

for

for in that case the report, which he does not deny to be a true one, must have been calculated to do him credit, and therefore could afford no just cause for offence. But how far what he said was, *in reality*, proper and commendable, the Reader will no doubt have formed some judgment, from what has been mentioned, p. 40, of my Narrative, relative to his statement of what he pretended had been communicated to him by Mr. Emery; his answer to which I shall have occasion to animadvert upon presently.

In p. 115, Dr. Maskelyne takes some pains to extol the merit and character of Mr. Arnold. He tells us his acquaintance with him was founded on a regard for his abilities, and that it was he who first recommended him to the Board of Longitude, by whose encouragement and rewards principally he has been enabled to bring his Time-keepers to their present degree of perfection. But in addition to this I must mention, that the weight of obligation, which the Doctor pretends to have conferred on Mr. Arnold, has not prevented the latter from complaining like others of the Doctor's conduct; and that upon his finally taking away some Watch or Watches, which had been under trial by the Doctor, he expressed himself with the most sovereign contempt towards him, and told him, that from

thenceforward, he for ever washed his hands of him. With respect to Mr. Arnold himself, I really do not wish to say any thing that should either hurt his feelings, or prejudice him in the opinion of the world; and I certainly should not have taken upon myself the invidious task of saying to the world, as to Mr. Arnold, or any one else, thus far should you allow merit and no farther; had not Mr. Arnold himself, by what he said, before my Narrative was published, in the Pamphlet I have already alluded to, in some measure rendered it necessary. Mr. Arnold dwells upon one thing in this publication, which I must take some notice of, in order to do away any improper impression it might make, relative to the practicability of bringing my Father's Time-keepers into general use. Mr. Arnold observes, that my Father has been twelve years making only two Time-keepers, and therefore if their excellence was allowed to the full extent, how few could be made in comparison of his Time-keepers. This certainly is a very unfair argument, even supposing the observation upon which it is founded to be a true one, which it is not*; for every one must, upon the least consideration, be sensible of the great difference between a thing that is already become

* It appears even by Dr. Maskelyne's Answer that the two last Time-keepers were made in *two* years. See p. 36.

an article of manufacture, upon the different parts of which many hands may be employed at the same time, and a thing that is made entirely by one single person. The first of my Father's Time-keepers was completed in somewhat less than three years, and, as it was then quite a new invention, much time must have been necessarily employed in making a variety of experiments in order to ascertain the precise effect of the principles intended to be made use of, and the most proper method of applying them; added to which it is likewise to be recollected, that my Father was, even then, near sixty years of age. The two last were made in about two years, and of the time that has since elapsed, much has been taken up in the various public and private trials: my Father also lost a considerable time by sickness*, and other unavoidable interruptions of different kinds. Indeed old age had at last so en-

* My Father was at one time confined to his bed and his lodging-room for several months together by a bad leg, and should the character Dr. Maskelyne has ascribed to him make it necessary to prove it, I am inclined to think, that upon an application to the Marquis of Lansdowne, his Lordship would have no objection to declare, that he was acquainted with the circumstance; for being at that time in the West of England he had the goodness, together with the late Lord Boringdon, and some other gentlemen, to honour my Father with a visit in his lodging-room,

tirely disqualified him for employments of this kind, that I have frequently heard him and his friends speak of his having finished some nice part of his work merely by the touch, his eyes having so far failed him, that, even with the assistance of glasses, they were not in this instance of any service to him. Hence it follows, that though the principles upon which the Time-keepers are made have, under the circumstances above stated, given to all the three so great a degree of excellence, it must reasonably be expected that other artists, who have younger eyes, and steadier hands, to execute what relates to the mere workmanship, would display the effect of those principles in their full extent, and give to the machines constructed upon them all the perfection they are capable of imparting, which my Father at his time of life was unable to do.

With respect to the probable time in which they might be made, were they to become an article of manufacture, I have, since I found it necessary to write this Reply, asked my Father to form the best judgment upon the subject he could, and he has told me he thinks they might very easily be made in about four months, or double the time necessary to make a common Watch. And as to what would be the probable price of them, I believe when

I mention

I mention 80l. I should not be found very wide of the mark, though I apprehend the price of Mr. Arnold's best Time-keeper is 120l. or guineas.

With respect to what Dr. Maskelyne says, of Mr. Arnold's Time-keepers being superior in simplicity and readiness of adjustment to my Father's, it is really somewhat extraordinary, that the Doctor should feel himself able to make the comparison. As Mr. Arnold's Time-keepers are an article of sale, the world may be well expected to be acquainted with the construction of them; but the construction of my Father's having hitherto been understood to be a secret, if Dr. Maskelyne knows it, I should be inclined to ask him how he acquired his knowledge; for while the Time-keepers were under his management, the cases were always locked up, so as to leave no part open, but that by which they were wound up; and no one could see the construction of them, except by breaking the lock, or making use of some other unfair method. Mr. Arnold I know has said, he is acquainted with their construction, but rather than rest upon mere assertion, if he really does know it, I will say, as a friend of my Father's did upon being told that he had said so, Let him give a description of it.

The

The Doctor charges me with having been very bold in my assertion, that Mr. Arnold, after having quarrelled with him, had, as a candidate for the rewards of the Act, had other Time-keepers under trial in the Doctor's hands, which had not gone, according to his account, at all within the limits of it. The Doctor does not however deny, either that Mr. Arnold quarrelled with him subsequent to the trial of the Time-keeper that went so accurately, or that he had afterwards other Time-keepers under trial in his hands, that did not, according to his account, go at all within the limits of the Act; which is every thing that was material in my assertion: I shall therefore not dispute with the Doctor, whether these Time-keepers were under trial for the specific rewards of the Act, or with a view to that encouragement, and those rewards, which he informs us the Board of Longitude have bestowed upon Mr. Arnold; neither of which are of any consequence to the object I had in view.

In the 117th and eight following pages of the Doctor's Answer, he has made a long, and imperfect, attempt to vindicate himself from what he is charged with having stated to the Board of Longitude respecting my Father, upon the supposed authority of Mr. Emery. It is undoubtedly true, as the Doctor observes,
that

that Mr. Emery never spoke to me in his life, and perhaps never exchanged three words with my Father; nor have I pretended that he ever did. But though I have not myself had any personal communication with Mr. Emery, it does not follow that what I have stated, as coming from him, must on that account be untrue; for it might turn out, upon enquiry, that the quarter from which I received my information, would probably occasion it to be considered by the major part of my Readers, as more to be depended upon, than if it had rested entirely upon my own authority. What was done by Mr. Emery for my Father did, as I have already observed in my Narrative, amount to nothing more than soldering two metals together, which, having nothing of novelty in it, might have been performed as well by other good workmen, and had no more to do with the invention, than the enamelling of the dial plate, or the polishing of the case. And it is not true, neither is it the language of my Narrative, though the Doctor is pleased to insinuate that it is, that my Father could not execute this part of the Watch himself, though in the country. What I observed was, that for want of proper conveniencies in the country, he could not have done it there, without more trouble than Count Bruhl wished

he should take, not that he could not have done it there at all. And so far from the compensation-pieces originally put by him into his Time-keepers not having answered, from having been made of bad metals, as the Doctor informs his Readers, the compensation-piece, which he originally put into his first Time-keeper, remains in it to this day, and, after a trial of eighteen years, is found to answer full as well, as any he has since made use of.

The Doctor charges me with inconsistency, for saying he ought to have given a candid and unequivocal account of all he knew relative to the invention, that the Commissioners might have been enabled to come to a decision, with all the knowledge upon the subject, which he was capable of communicating; when, as he thinks fit to say, I had a little before blamed him for acquainting the Board with the assistance, which he says Mr. Emery gave my Father in constructing the thermometer part of his Watches. But the Doctor must have been exceedingly inattentive, when he read this part of my pamphlet, unless it was his intention purposely to misrepresent it. For, if he will take the trouble of looking it over again, he will find, that I have expressly blamed him for not giving the Board an account of all he knew; but, on the contrary, bringing forward
a hasty

a hasty expression, which he had extorted from Mr. Emery, when he thought it was calculated to do the most mischief, and was most likely to be understood in the sense he wished, without any explanation how it was obtained, or what was meant by it, for the purpose of influencing their determination.

The Doctor dwells much, p. 120, upon the Watch which Mr. Emery made with my Father's scapement, stating, that he was not, when he supposed Mr. Emery had copied from my Father, "so well apprised, as he was then, "of Mr. Emery's merit as a good workman, "and ingenious watch-maker, as to make him "ready to imagine him capable of executing a "Watch of such excellence, as that evidently "appeared to be from Count Bruhl's trial of "it, with the help *only* of Mr. Mudge's scape- "ment, supplying himself, out of his own in- "vention, the *many* other *essential* parts of a "watch, nay *more* essential parts in the opinion "of the principal makers of Time-keepers." He then quotes Count Bruhl's words, calling it a watch "executed in imitation of the model of "a scapement invented by Mr. Mudge about "30 years before (about 1754), which model "he made at his (the Count's) request, in order "that so valuable an invention might be brought "into more general use:" and adds, that "these

" words seem to imply, that the escapement
 " was the principal thing in the Watch, and
 " that Count Bruhl had, he believed, confi-
 " dered this Watch, from this circumstance,
 " as if it had been Mr. Mudge's Watch, exe-
 " cuted by Mr. Emery; in which opinion,
 " perhaps, he had been carried too far by his
 " great attachment to Mr. Mudge." In reply
 to this, I must observe, that the only things in
 which modern Time-keepers differ essentially
 from those made formerly, and to which they
 owe almost the whole of their superiority, are
 the application of a thermometer, and the par-
 ticular construction of the scapement; and
 though the Doctor talks of the many other *es-*
sential parts of this Watch, besides the scape-
 ment, nay *more essential* parts, in the opinion of
 the principal Time-keeper makers, it is a fact,
 that the scapement is the principal things in
 this Watch, as Count Bruhl had very justly
 observed, and that it does not in any other
 essential point differ from other Time-keepers.
 To put the question, however, entirely out of
 dispute, and shew that the Doctor's assertions
 are totally ill founded, the Count, whose pro-
 perty the Watch is, is very ready to suffer it
 to be taken to pieces, and examined, by any
 ingenious Artist, whom he has no doubt of
 convincing, that the scapement is not only the
 principal

principal part of this Watch, in which it differs from other Time-keepers, but is the part to which it is *principally* indebted for its superior excellence.

The Doctor tells us, p. 124, that Mr. Emery had said, that the two Watches, which he had presented to the Board, had a different escapement from Count Bruhl's Watch, and of his own invention : and then adds, that he thinks he has now vindicated Mr. Emery from the suspicion of having borrowed the construction of these Watches from any communication of Mr. Mudge's inventions, and at the same time shewn him not to be deserving of the reproaches, which he understands have been thrown upon him by some of Mr. Mudge's friends, as if he had prevented him from receiving the reward. The Doctor must certainly have been very much at a loss, when he wrote such a passage as this, and the Reader will perhaps be a little surpris'd, when he is inform'd I never brought any accusation against Mr. Emery of having borrowed the construction of the Watches he presented to the Board from any communication of my Father's invention ; the Doctor's vindication of him, therefore, is perfectly useless : nor do I know that my Father, or any of his friends, ever reproach'd him with having prevented him

him from receiving the reward, or that they ever entertained the most distant idea of his having so done.

We are next told, p. 125, that I have after all, in p. 43 of my Narrative, owned myself at a loss to account for the Doctor's enmity to my Father's success; which the Doctor says contradicts what I had said before, in the note p. 4, of his having a private interest to induce him to wish ill to mechanics, as being candidates for the same prize of the Longitude with himself; which, he tells us, shews, that I did not believe what I there asserted. This charge appears very specious upon the face of the Doctor's Answer, but it turns out upon examination, that he has contrived to make it so, by a little management, having totally omitted to notice some very operative words of the passage he reasons upon. As he has not thought proper to lay it fairly before the Reader, I shall do it for him. The passage is as follows;—

“ Indeed, when one considers *the whole* of Dr. Maskelyne's conduct, one can hardly tell how to account *entirely* for his enmity to my Father's success. It has been suggested to me, and possibly it may be true, that it has been in part occasioned by my Father's avoiding to court his patronage and favour;

if

"if this be true, though I am sorry for the effect, I cannot lament the cause," &c. &c. I had previously mentioned, what appeared to me to be some reason for the Doctor's not wishing well to mechanics in general; but, upon a view of his whole conduct, I professed myself at a loss how to account *entirely* for his enmity to my Father in particular, and then proceeded to state something else, which might probably have contributed towards it. Whether there be any thing contradictory in this, or any thing that shews I did not then believe, what I had before asserted, the Reader will judge.

The Doctor afterwards charges my Father with *ingratitude, indecency, and assurance*. Whether his conduct through life has rendered him deserving of these epithets, I must leave to the judgment of those who know him, and among them are many of the most distinguished characters in the kingdom. Were I inclined to indulge, what some persons might deem an excusable resentment, I think I should have no great difficulty in retorting this charge upon the Doctor himself; but I really think there is something so extremely illiberal in it, that I am not at all disposed to dwell upon it any longer. I shall therefore only observe, in opposition,

position to what the Doctor has said, of my having endeavoured to traduce the Board of Longitude; and bring them into contempt; that I never made use of any expression tending to convey an idea, that I supposed they had any concern with what the Doctor had done; but, on the contrary, expressly stated, that I did not attribute to any one member of that Board, except Dr. Maskelyne, the least disposition to treat my Father with want of justice or candour; though the Doctor evidently appears to wish them to adopt what he has done, that he may shift part of the censure from his own shoulders, and transfer it to theirs.

At the close of his book the Doctor tells the Public, that the Board of Longitude deserve commendation for having been careful concerning the distribution of the public money, and insinuates, that they would have been censurable, if they had given any of it to my Father, whom he elsewhere, in the same paragraph, styles an *interested Watch-maker*, and a *disappointed Artist*. I most readily admit, that it was my Father's wish to obtain from the Public such a reward for his labours, as from their merit, and usefulness, he might be thought fairly entitled to; but I at the same time say, that if, in order to accomplish that purpose, he

had

had found it necessary to make any sacrifice of honour or integrity, he would not have consented to relinquish the only principles, that confer real dignity upon human nature, for the greatest reward the Public could have bestowed upon him.

Having now finished my remarks on Dr. Maskelyne's Answer, I shall just observe, before I conclude, that were I at all disposed to indulge myself in invectives, as the Doctor has supposed, I should have an opportunity of reaping an ample harvest, by summing up what I have proved against him; but the Doctor is mistaken in thinking me capable of feeling any pleasure of this kind. My only motive is now, as it was when I first made my appeal to the Public, to vindicate the reputation of an aged Father, who is entitled to all the zeal and activity I can exert for him; to state his claims impartially to the Public; and to obtain for him that countenance, and support, to which his long, and successful, labours have so justly entitled him. When I have done this, I shall have accomplished every thing I had in view, and beyond it I am not conscious of the influence of a single principle, that would induce me to act hostilely towards any one. But I feel it as much a duty incumbent upon me at present, to reply to the

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Doctor's

Doctor's Answer, as it was some months since to write my Narrative; for though I place great confidence in the goodness of my Father's cause, I was told by a celebrated Member of the House of Commons, just before the publication of the Doctor's Book, that he feared my application to the House would be much prejudiced, by a plausible Answer, which he understood Dr. Maskelyne was writing. Being of opinion, upon the perusal of it, that my Father's case was rather strengthened, than weakened, by what the Doctor had advanced, I now lay the observations I have made upon it before the Public, who, I have no doubt, will determine between us with the strictest justice and impartiality.

I cannot, however, suffer this publication to go into the world, without availing myself of the opportunity it affords me, of expressing the grateful sense I have of the very generous conduct of Mr. Windham, who though in habits of great intimacy with the friends of both parties, notwithstanding he found it to be an enquiry attended with much soreness, has never testified the least inclination to relinquish the part, which, at the request of some of my friends, he has taken in the business;

business; but on the contrary has from the commencement of it shewn the most ready disposition to do what has been requested of him, provided he thought it compatible with candour and justice.

F I N I S.

but not, but on the contrary has from the
one aspect of it, on the other hand, the
good one is a very good one, and of him
we should be proud to compare it with any
other one.

It is a very good one, and of him
we should be proud to compare it with any
other one. It is a very good one, and of him
we should be proud to compare it with any
other one.

1

It is a very good one, and of him
we should be proud to compare it with any
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other one.

A
SHORT EXPLANATION

OF THE
MOST PROPER METHODS OF CALCULATING

A
MEAN DAILY RATE,

WITH

A few Remarks on some Passages extracted from
the Rev. Dr. MASKELYNE's Answer to
Mr. MUDGE's Narrative.

By the COUNT DE BRUHL.

———— Absentem qui rodit amicum,
Qui non defendit, alio culpante —————
hic niger est.

SHORT EXPLANATION

OF THE
MOST PROPER METHODS OF CALCULATING

A
MEAN DAILY RATE

WITH

A few Remarks on some Principles extracted from
the Rev. Dr. Mather's Answer to
Mr. Mather's Narrative.

By the Count de BRUNH.

Adresser des lettres anonymes.

De l'imprimerie de
M. de la Harpe.

SHORT EXPLANATION, &c.

THE regularity of all machines made for the purpose of measuring Time, can only be ascertained by comparing their motion with an invariable standard or scale, such as mean solar, or sidereal, time. If either of these be represented by the line A O, Fig. 1, in which A is the origin of the abscissæ, each of which indicates twenty-four hours; and if a watch be supposed to measure every day exactly twenty-four hours, its regularity may then be expressed by the axis A O. But if, instead of so perfect an agreement of its motion with the assumed scale, it should every day differ from it equably, it would then have a *rate*, which, as

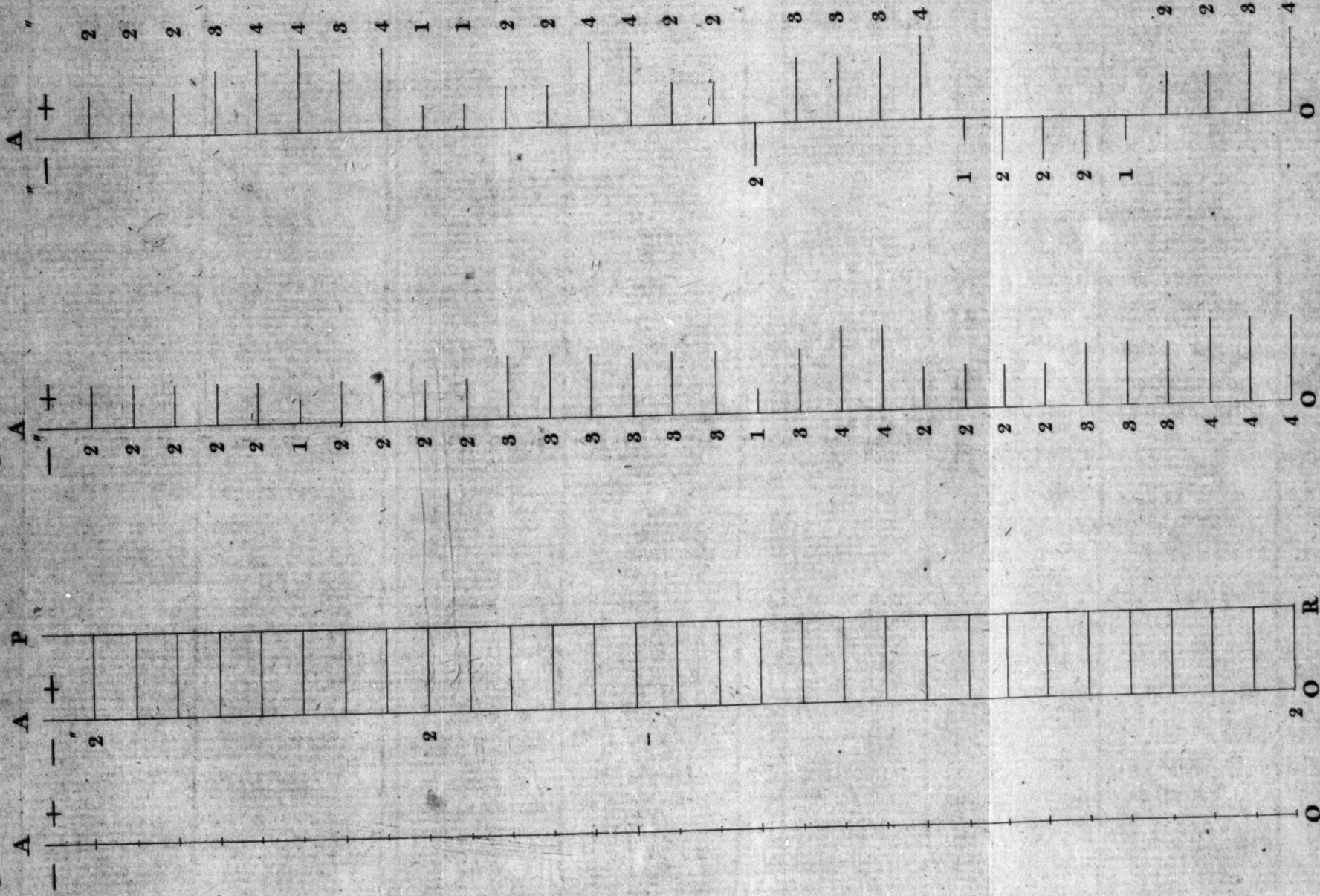
in Fig. 2, might be expressed by equal ordinates, and the regularity of that rate by the line P R, drawn parallel to the axis A O ; nor will it signify on which side of the axis the ordinates, which determine the distance of that parallel line from it, happen to fall, provided the sign be known to which they belong. But, if the daily variations be unequal, they either fall on one side of the axis, as in Fig. 3, or as in Fig. 4, partly on one, and partly on the other side, under the opposite signs + and —. In both cases recourse must be had to a method of computation to find what is called a *mean daily rate*, which may be done two ways, viz. by taking the arithmetical mean between two extreme daily variations, or between them all together. The subjoined examples under the Fig. 3 and 4, will sufficiently illustrate both methods. As to the probability, that a mean daily rate, deduced from a series of observations, will nearly give the motion of a watch for another period, during which it cannot be ascertained, it is obvious that it must be in the ratio of those periods. If, therefore, the preceding period of trial be considered as a constant quantity = 1, and the duration of several succeeding periods be expressed by 1 . 2 . 3 . 4 . 5 . 6, we shall get the fractions $\frac{1}{1} \cdot \frac{1}{2} \cdot \frac{1}{3} \cdot \frac{1}{4} \cdot \frac{1}{5} \cdot \frac{1}{6}$ to represent the probabili-

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



Examples of computing a mean daily Rate

By the first method } $\frac{4+1}{2} = 2.6$ } $\frac{4+1}{2} = 2.6$ } $\frac{4+(-2)}{2} = +1$ } $\frac{64+(-10)}{30} = +1.8$ }

second D. } $\frac{78}{30} = 2.6$ } $\frac{64+(-10)}{30} = +1.8$ }

ty belonging to each of the subsequent periods. The case may be supposed of two sea Captains, of whom the one is going to sea for one month, with a watch which has undergone a previous trial of six months, and the other setting out for a voyage of six months, with a watch that has been tried during only one month: if it be asked what proportion the reliance, or confidence, which the former may place in his watch, bears to that with which the latter can reasonably confide in his? the answer will be as 36 is to 1. Here is the proof of that solution: Put P L for the period of a previous trial of six months, P S for a trial of one month, C for the degree of confidence belonging to P L in respect of a voyage of one month, c for the confidence belonging to P S during a voyage of six months, then forming the analogy, $C : c :: P L : P S$, substituting in the room of the two first terms their values, we get $C : c :: \frac{6}{1} : \frac{1}{6}$, reducing to the same denominator in order to expunge it $C : c :: 36 : 1$.

Those who maintain, that since a short trial can be more easily obtained, it ought therefore to be preferred to a longer trial, draw a conclusion from premises which these do by no means warrant. To carry conviction into minds of such a cast, is a task to which I have

have not the presumption to think myself equal. It has been likewise urged in favour of a short trial, that a rate deduced from a long period, such as six months, being applied to another in succession of the same length, a very indifferent watch may, by a compensation of opposite errors, appear to have been free from any at the expiration of the latter period. To this objection I reply, that by a very uncommon chance indeed, it might so happen, if no judgment were to be formed of the regularity of a watch, but on the result which might be obtained at the expiration of the period succeeding to that from which its rate had been deduced. But who attempts to lay down such a fallacious rule? It was certainly never intended by me, nor by any one of those who concur with me in the principles on which all investigations of that sort should be instituted. According to our conceptions of the matter under consideration, the mode of proceeding in a trial made at land, with a view to judge thereby, how far a watch may afterwards be depended upon at sea, should be, 1st, To establish a rate from observations continued for a period of an equal length, at least, with a subsequent period. 2dly, To divide this into several aliquot parts. and 3dly, For each of these in particular to compare the
difference

difference between the time shewn by the watch and mean time, with the sum of its daily rate, by which means, every error of the watch would be discovered, and accurately ascertained.

Extracts from Dr. Maskelyne's Pamphlet, No. 1, from page 72. " The accuracy of
 " the determination of the longitude to one
 " mile and a quarter in the first voyage, and
 " six miles and an eight in the second, is indeed very surprising. No account is given
 " whether any rate was allowed for the going of the Time-keeper in these voyages,
 " the want of which renders the result dubious. But I find, by Count Bruhl's calculations of the going of Mr. Mudge's first
 " Time-keeper in the first voyage annexed to the three registers of his Pocket Chronometer, made by Mr. Emery, which he
 " made me a present of long ago, that the longitude of St. John's was found in the
 " going out to be $3^h 29' 37''.7$ (when an evident erratum of $10''$ is corrected), and
 " $3^h 29' 53''.8$ in the return, which differ only one second each from those mentioned
 " in the last page of Mr. Mudge's pamphlet; and in these determinations no allowance has been made by the Count for the
 " daily rate of the watch, which, by Admiral
 ral

"ral Campbell's observations, made at New-
 "foundland between July 4, and October 24,
 "1784, printed with the above-mentioned
 "registers, by Count Bruhl, and inserted also
 "in the last page but one of Mr. Mudge's
 "pamphlet, was $+0^{\circ} 94'$. This, in thirty-
 "seven days, the length of the voyage out,
 "makes $34'' 7$, which, subtracted from $3^h 29'$
 " $37'' 7$, leaves the longitude of St. John's
 " $3^h 29' 3''$ by the voyage out, or $41''$ less
 "than the true longitude. The same daily
 "rate in twenty-six days, the length of the
 "voyage home, makes $24'' 4$, which added
 "to $3^h 29' 53'' 8$, gives the longitude of St.
 "John, $3^h 30' 18'' 2$ by the voyage home, or
 " $34''$ greater than the true longitude."

The particulars in this extract, of which I
 shall take notice are, 1st, The difference of
 $1''$ between the numbers printed at the con-
 clusion of the registers of my watch, and those
 on the last page but one of Mr. Mudge's
 pamphlet. 2dly, The omission of an allow-
 ance on my part for the Time-keeper's daily
 rate. 3dly, The corrections which the Doctor
 applies to my calculations.

imo. At the time of printing the registers
 of my Chronometer, I estimated the longitude
 of my house at $32'' 5$, which, about a year
 afterwards, I had opportunities to investigate
 more

more minutely, as will appear from the following detail :

1786, April 16th. Soon after I had observed the $\odot$'s meridian passage, I went in my carriage to Mr. Aubert's Observatory, at Loampit-hill, carrying with me my own watch, and Mr. Mudge's first Time-keeper.

Time shewn by Mr. Aubert's	h	'	"
clock - - -	3	12	0,0
Acceleration of the clock	—	2	14,4
Sidereal time -	3	9	45,6
$\odot$ r viz. Complement of the			
$\odot$'s mean long. at noon	22	20	53,647
Sum -	I	30	29,247
Acceleration	—	14,854	
Mean time	I	30	24,393
By the Time-keeper ditto	I	29	56,200
Difference of meridians	0	0	28,193
Ditto of Loampit-hill and			
Greenwich - - -		+	5,400
Longitude of my house	0	0	33,593

In the evening I walked to the Royal Ob-
 * C servatory,

servatory, in company with Mr. Aubert and Dr. Zach, where we were very politely received by Mr. Linley, and having compared my watch with the clock, I found the following result:

Time shewn by the Greenwich clock	-	-	h	'	"
Acceleration of the clock	-	-	8	43	0,0
			—		17,0
Sidereal time			8	42	43,000
Or compliment of the ☉'s mean longitude at noon			22	20	53,647
Sum	-	-	7	3	36,647
Acceleration	-	-	—	1	9,395
Greenwich mean time			7	2	27,252
Dover-street ditto, by my watch			7	1	53,650
Longitude of my house			0	0	33,602

2do. The omission of an allowance for the Time-keeper's rate in my calculations, is, I am ready to allow, a very fit subject for the learned Astronomer's animadversion; so that after having made that concession, I shall proceed to the third point, viz. his calculations of

of a rate, by which he has taken the trouble to correct mine, and observe, that the rate on which the Doctor has built his corrections, is not that which he ought to have employed; and that another rate, for the calculating of which I had supplied him with the requisite materials, should have been taken by him for the ground of correcting the two of the late Admiral's observations. The data to which I allude, are the quantity, which the Time-keeper was slow May 28th, and that which it was fast Nov. 19th, for the meridian of my house. If it had pleased the Doctor to divide their sum by 175 days, the quotient would have given him $+ 0''.51$ for the Time-keepers daily rate; and for the proof, that this rate ought to have been chosen by him, in preference to that which he has adopted, I refer him to the preceding explanation, in which I hope, that I have clearly shewn, from sound mathematical principles, that the application of a rate, deduced from the longest period, affords the greatest probability, that it will represent the subsequent motion of a watch within the most contracted limits of error. The following calculations will therefore, I trust, sufficiently evince the truth of that doctrine:

1784, July 4		
Time-keeper fast for the meri-		
dian of St. John	-	3 28 29,40
(a) Ditto slow for Dover-street		
May 28th	-	+ 25,75
(b) Longitude of ditto from		
Greenwich	-	+ 33,60
Sum of daily rate at + 0,51 in		
37 days	-	18,87
Longitude of St. John by the		
Time-keeper	-	3 29 29,88
True longitude of ditto		3 29 44,0
Error of the determination in		
defect	-	0 0 14,22
1784, Oct. 24, Time-keeper		
fast, &c.	-	3 30 24,90
a + b	-	+ 59,35
Sum of daily rate at + 0"51 in		
149 days	-	1 23,99
Longitude of St. John by the		
Time-keeper	-	3 30 0,26
True longitude of ditto		3 29 44,0
Error of the determination in		
excess	-	0 0 16,26
Arithmetical mean of both de-		
terminations	-	3 29 45,14
		Which

Which differs from the true longitude $1^{\circ}, 14'$.
 I had the curiosity to repeat the same process
 with another of the Admiral's observations
 of August 31, 1784, which, as it falls nearly
 between his first, and his last, observation, I
 considered as the most proper test of the rate
 which I have chosen; and to save the learned
 Astronomer the trouble of computing a sum
 of daily rate for that particular observation,
 I will give him my computation at length.

1784, Aug. 31. Time-keeper	"	"	"
fast for St. John,	-	3	29 28,60
a + b	-	-	+ 59,35
Sum of daily rate at $+ 0^{\circ}, 51'$,			
in 95 days	-	-	- 48,45
			3 29 39,50

Arithmetical mean of this and
 the two preceding results, 3 29 43,21
 Which again differs not quite one second from
 the true longitude.

Second extract from pag. 72, and 73:

" I hope this elucidation of the longitude
 " of St. John's, given by the Time-keeper,
 " which I have been accidentally enabled to
 " derive from the papers which Count Bruhl
 " had furnished me with formerly, will shew
 " the necessity of proper details being given
 " relating

" relating to experiments of this nature, and
 " the insufficiency of any general account of
 " such things ; especially where consequences
 " are attempted to be drawn of such import-
 " ance as Admiral Campbell's inference, that
 " the Time-keepers are capable of answering
 " every nautical purpose that can be required
 " of them : upon which, Mr. Mudge says im-
 " mediately afterwards, great weight should
 " be laid, on account of the Admiral's scien-
 " tific knowledge and accuracy of observa-
 " tion, for both which he was deservedly
 " looked up to in the navy. If the Admiral
 " ever made such a declaration, *which I much*
 " *doubt*, he was probably led into it from the
 " *mistaken calculations* of the Count, for which
 " himself he was not answerable."

Whether my calculations deserve the flat-
 tering epithet, which the Doctor has bestowed
 upon them, I shall leave to the decision of
 those who have done me the favour of reading
 the preceding disquisition ; where, in conform-
 ing to the Reverend Gentleman's rule, I have
 given proper details, which fully warrant the
 the inferences, which I have drawn from
 them. But I feel very happy to be able to
 relieve the learned Astronomer from the pres-
 sure of the doubt which he entertains, whether
 the Admiral ever made such a declaration, by
 assuring

assuring him, that I have often heard the Admiral declare, that no better machines need be required, and that from his own experience of the Time-keeper, which I lent him in his two voyages to and from Newfoundland, he was fully convinced of the great utility which might be derived from their use at sea.

Dr. Maskelyne, page 121, speaks of my great attachment to Mr. Mudge. To that charge I must plead guilty, and bear with resignation any blame or reproach, arising from my partiality for a man whose superior genius as an artist, united with the liberality of a mind replete with candour, simplicity, modesty, and integrity, deserve the highest admiration and respect; whose name will be handed down to the remotest posterity, with the same veneration which attends the names of his predecessors in the same line, Tompion, Graham, and Harrison, who, while living, were admired by their cotemporaries, and whose fame adds to the splendour and glory of this great nation, which I am confident is too much enlightened to approve of, and still less to adopt, the universal proscription held out by the Reverend Astronomer Royal, against any foreigner, who does not pay an implicit obedience to his dictates.

Before

Before I take my final leave of the learned Gentleman, I will inform him that Dr. Zach has lately published Solar Tables, where, p. 125, he will find some of those assertions refuted with which the Reverend Doctor has indulged his spleen against that Gentleman; who, notwithstanding my two unsuccessful attempts to obtain for him the honour of being elected a Fellow of the Royal Society, supports that mortification with a becoming fortitude, and derives some small consolation from the high esteem in which he is held by the learned, as a first-rate Mathematician, and an incomparable practical Astronomer.



